DEC 9 1943

The Engineer

VOL. CLXXVI—No. 4583 28, ESSEX ST., STRAND, LONDON, W.C.2 NOVEMBER 12, 1943

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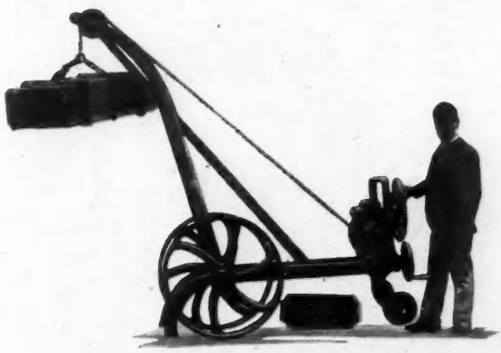

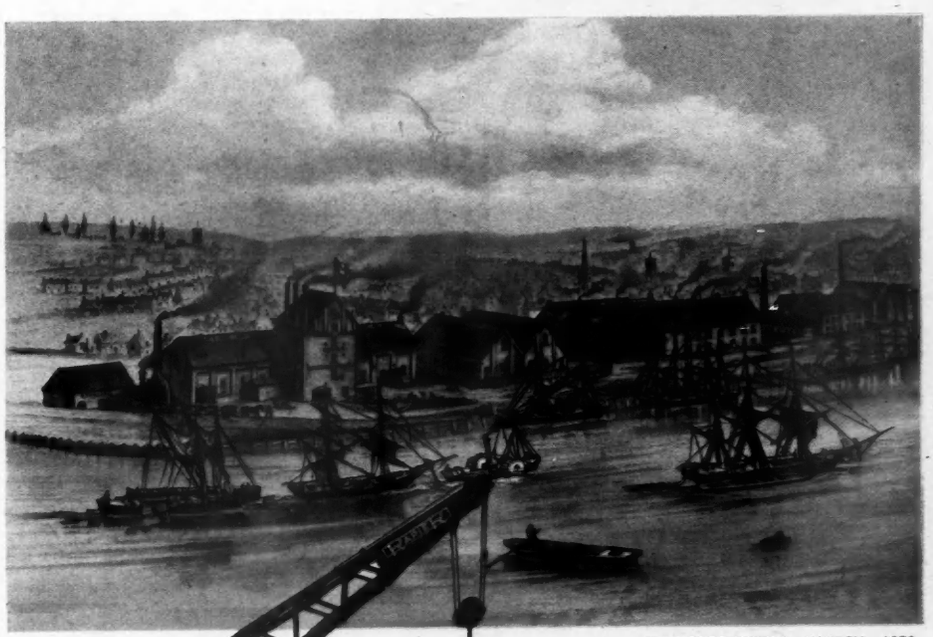

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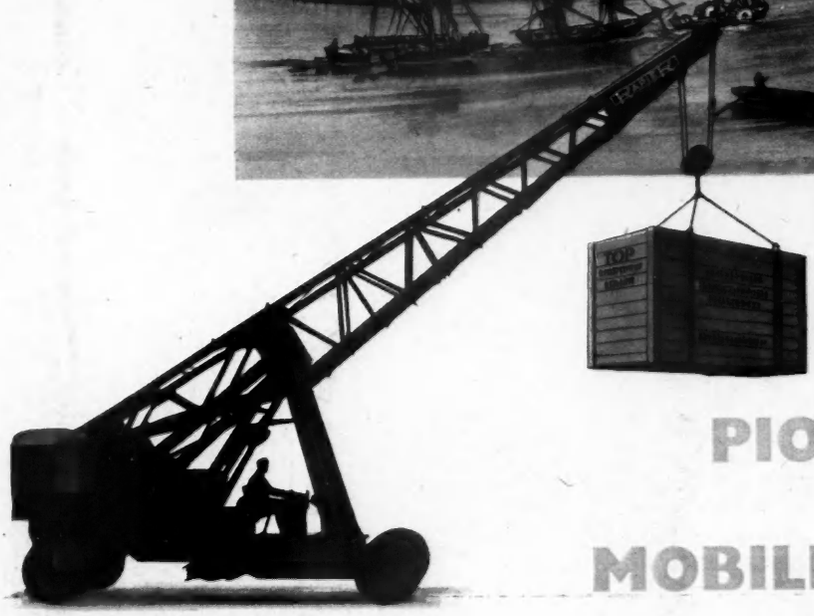

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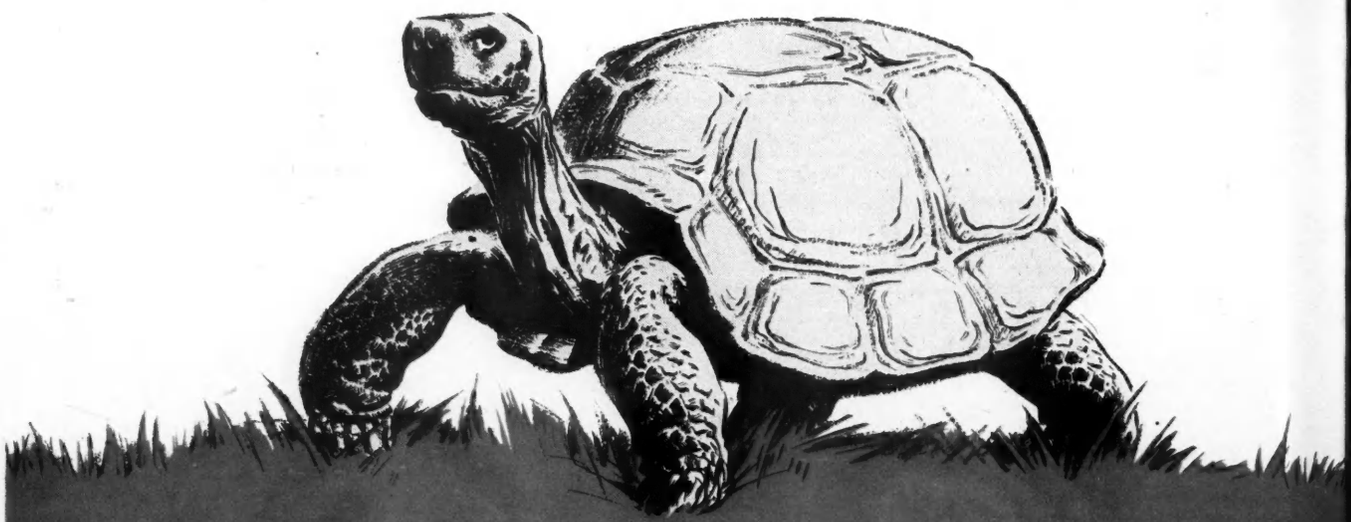

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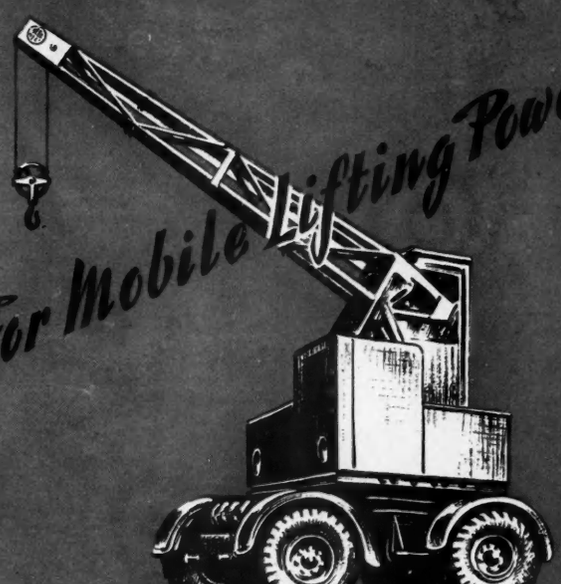

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The Engineer

LONDON, FRIDAY, NOVEMBER 12, 1943.

PUBLIC NOTICES

GOVERNMENT OF INDIA

DEPUTY DIRECTOR OF MANUFACTURE AND PLANNING

The Ministry of Labour and NATIONAL SERVICE invite APPLICATIONS for the POST of DEPUTY DIRECTOR of MANUFACTURE and PLANNING in the Aeronautical Stores Division under the Government Stores. Appointments will be for the duration of the war with a minimum period of one year, subject to three months' notice on either side. Passage both ways is provided. Bonus on completion of service.

QUALIFICATIONS REQUIRED.

DEPUTY DIRECTOR.—Manufacture and Planning Aeronautical Stores Division. Good general experience, ability to Handle Contractors. Age not more than 45. Sound Mechanical Training and at least five years' subsequent Supervisory experience in recognised Mechanical Workshop. Drawing-Office experience desirable.

PLANNING.—Planning Design and Manufacture of Gauges for Quantity Production Aircraft Metal Components produced either by precision machine methods with heat treatment or by press tools.

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8533

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TYPES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the advertisers. These notices (limited to one line) will be free of charge, and co-operation is invited thereby.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

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1941 No. 2069
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ASSISTANT PLANNING ENGINEER REQUIRED by large firm in South England manufacturing Metal and Wood Components. Salary £500 to £600, according to qualifications and experience.—Applications, in writing (no interviews), stating date of birth, full details of qualifications and experience, including present employment and quoting reference No. 274, should be addressed to MINISTRY OF LABOUR AND NATIONAL SERVICE, Appointments Officer, 16, Westwood Road, Southampton. 8547 A

DEPARTMENTAL MANAGER REQUIRED for Heat Treatment Department, Steel Works, North Midlands; must have had practical experience and technical education, capable of organising ability, and experienced in Labour control (this is important). Permanent position. Salary £600 per annum. State age and experience chronologically.—Address, P6420, The Engineer Office. P6420 A

The Engineer

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THE FACT that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

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THE Post You Are Seeking May Not Be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

SITUATIONS WANTED

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***Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of* THE ENGINEER.**

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A Seven-Day Journal

Bomb and Fire Damage at Kassel

On Friday night, October 22nd, Kassel was attacked by aircraft of Bomber Command for the second time, and over 1500 tons of high-explosive and incendiary bombs were dropped. The raid was so concentrated that at its end many great fires in the town were sending up columns of smoke to a height of 18,000ft. These fires continued to burn for seven days, and photographs taken by reconnaissance aircraft which have just been examined by the Air Ministry show that of 315 acres in the fully built-up area, 300 acres have been devastated, while in the remainder of the town, excluding the suburbs, just under half has been destroyed. In all, it is stated by the Air Ministry news, fifty factories were either destroyed or damaged, among them being many establishments which have the highest priority in the German armament programme. The most important are undoubtedly the three locomotive works of Henschel and Sohn A.G., a firm which has now been established for over 133 years. In these works before they were attacked about one-third of Germany's output of locomotives was produced. Before the Battle of the Ruhr and the destruction of Essen, referred to in our issue of October 29th, Krupps were the largest producers of locomotives in Germany. When, however, the large locomotive shop was hit at Essen, Henschel's then became Germany's largest locomotive builders. The importance of their three factories in Kassel can hardly be exaggerated. All three, the original works near the centre of the town, the second at Rothenditmold, and the third at Mittelfeld, suffered damage, which was most marked, we are given to understand, in the case of the original works in the centre of the town, which has been so badly damaged that it must be considered a total loss.

Anglo-American Steel Survey

An Anglo-American Mission, after a five-months' globe-circling tour, entailing a journey of some 48,000 miles, has completed a special survey of steel production and use in several of the Dominions, in India, and in the Middle East. The report and recommendations emphasises once again the advantages to the war effort which flow from combined action by the United States and Great Britain under the guidance of the Combined Boards. The results of the survey made with a view to securing the greatest possible measure of co-ordination between steel control systems operating in America and in the various parts of the British Commonwealth, including Great Britain, have been reported to the Steel Committee of the Combined Raw Materials Board and the Combined Productions and Resources Board. The Combined Steel Committee, headed by the operations Vice-Chairman, Mr. H. S. Batcheller, was established to obtain information on the steel production and requirements of the United Nations for the Combined Boards and to reconsider the means of improving the efficiency of the distribution and use of steel. The survey by the Mission, undertaken under this general responsibility of the Combined Steel Committee, "constitutes a major contribution to the United Nations' war effort." Mr. Batcheller has said: "It is hoped that with the information obtained from the various Domionions and India, it will be possible for the Combined Boards to complete the Allied Nations' balance sheet of steel production and requirements." The Mission consisted of Sir John Duncanson, Controller of the British Iron and Steel Control, and Mr. Earl A. Emerson, president of Armco International Corporation, of Middletown, Ohio. They were accompanied by Mr. Norman Anderson, of the British Iron and Steel Control, and Captain Alexander H. Gaal, A.U.S. Visits were made to New Zealand, Australia, India, South Africa, and the Middle East. The report also covered Southern Rhodesia, although that country was not visited by the Mission. The Mission made four recommendations to the Combined Committees:—(1) That there should be established in Great Britain an organisation to co-ordinate information on British and American steel controls and to circulate such information among the Dominions. (2) That the Dominions should be asked to advise this co-ordinating body of savings they have been able to make, and the method used, to be considered for adoption by the United States and Great Britain. (3) That a careful study should be made of any further surplus capacity arising in the Dominions, so that one Dominion might supply more of the requirements of another. This would, of course, save shipping space for other essential purposes by easing the burden on the United States and Great Britain. (4) That when standardisation of controls is completed, all steps possible should be taken to facilitate action on requirements submitted to Great Britain and the United States by the various Dominions.

Air Force Petrol Consumption

In the course of an address given to the Rotton Park Air Training Corps in Birmingham on Monday, November 8th, Mr. Geoffrey Lloyd, the Petroleum Secretary and the Chairman of the Oil Control Board, dealt with the petrol consumption of a modern air force. During the past week, he said, military operations had taken place which had made history, not only in air warfare, but also in petrol consumption. He referred particularly to the record-breaking assaults by the Air Force of the United States 8th Army and the Royal Air Force on the naval base at Wilhelmshaven and Düsseldorf within the space of twenty-four hours. The quantity of petrol which had been consumed during the course of these historic operations amounted to the colossal figure of nearly 5,000,000 gallons. That fuel, he said, was necessary to provide the motive energy for engines of over 4,000,000 H.P. which propelled the aircraft carrying the great bombs and the many thousands of men who formed the air crews. The fuel requirements of the two Air Forces were already on a vast scale, and their needs would grow as the promised expansion took effect, both in the size of the forces and the intensity of operations. Steps had already been taken, Mr. Lloyd went on to say, to build up petrol stocks in anticipation of these welcome events, but, however high those stocks might be, the demand was, and would always be, on a proportionate scale. Consumption must be made good by replenishment, and stocks must always stand at a level which was adequate to meet in full a succession of operations which might even be on a scale larger than that to which he had referred.

Disposal of Surplus Government Goods and Factories

Speaking in the House of Commons last week, in reply to a question by Mr. Rhys Davies, Mr. Hugh Dalton, the President of the Board of Trade, dealt with the post-war disposal of Government goods and factories. The Government, he said, had decided that disposal would be carried out in each case through the Department mainly concerned with the wartime supply of the goods. Before working out plans for disposal, the Board of Trade and other responsible Government Departments would consult with representatives of the producers and distributors concerned. The Government had further decided, Mr. Dalton said, that the Board of Trade, through its factory and storage control, should co-ordinate the disposal of all surplus Government factories, with a view to decisions being taken as to the best use to which they could be put in the national interest. The control would compile lists of factories and the applications for them. The Government recognised the importance of reaching such decisions before the end of the war in as many cases as possible, but this would depend on the course of events and the nature of future programmes of war production. Special attention, Mr. Dalton said, was being paid to the release of factories urgently needed for peacetime production and to the possibility of converting into trading estates some of the premises which were no longer required for Government work. The Government retention of factories was not ruled out and particular regard would be paid to the employment aspect of the case in each locality. The consultations between the Departments concerned and the representatives of the producers and the distributors would include representatives of the trade unions in the industries concerned.

The War Against U Boats

On Tuesday, November 9th, a statement was issued by the Prime Minister and the President of the United States dealing with the war against enemy submarines during the month of October. It says that during the three months of August, September, and October approximately 60 U boats were destroyed. This brings to more than 150 the number of U boats destroyed during the last six months. The record of the last three months is particularly gratifying, because during most of this period fewer U boats were operating and fewer targets were thus presented for our air and sea forces. During August, September, and October more U boats were destroyed than allied merchant ships were sunk by U-boat action. The ratio of U boat to merchant ship attrition during October was more satisfactory than in any previous month. Our tonnage losses from all causes in October were the second lowest of any month of the war. Merchant ship tonnage lost to U-boat action during the last three months was less than one-half the merchant ship tonnage lost during the previous three months, despite the fact that actual shipping increased. The Germans have introduced new U-boat weapons and tactics. Thus far, we have been able to cope successfully with the changing situation. The battle continues in full vigour.

Open-Cast Coal Mining

In the House of Lords on Tuesday, November 9th, replying to a question by Lord Barnby on the present and future policy of the Government with regard to open-cast mining, it was stated by Lord Portal, the Minister of Works, that it was the Government's policy to increase the production of open-cast coal to the fullest possible extent. Up to date, he said, 5,000,000 tons had been produced, of which total, 2,900,000 tons had been produced since last May, the beginning of the present coal year. Production was largely dependent on the weather, and roughly about double the quantity could be produced in the summer than in the winter. The increased production had been brought about by the co-operation of the civil engineering contractors, who had formed a committee to work with the Director of Open-Cast Production in the Ministry of Works. A considerable stock of coal was now in reserve, and plans were being pushed forward to enable it to be screened and loaded on the railways and canals. Steps had been taken to ensure the cleanliness of the excavated product. Open-cast coal was now being used by a number of industries instead of higher-grade coal. Those measures should be continued and expanded. Great efforts would still have to be made by industrial and domestic consumers in the future. The production programme for the coal year 1944–45 could only be carried out if a very considerable increase in plant was made available to begin operations in April next. For this purpose the Director of Open-Cast Production had visited the United States, and a programme of plant and requirements had been agreed by the United States Government, and it was hoped that additional plant would be available in the near future. We had still a representative in the United States to let us know how the programme progressed. A maximum number of excavators would be allocated to open-cast coal. Outcrop coal had already been sent for operational purposes to North Africa and Sicily. It was hoped next year to arrive at a figure of production in the region of 10,000,000 to 15,000,000 tons. To do that depended entirely on getting the necessary machinery.

Salvage at Pearl Harbour

(By an American Correspondent)

No. IV—*(Continued from page 359, November 5th)*

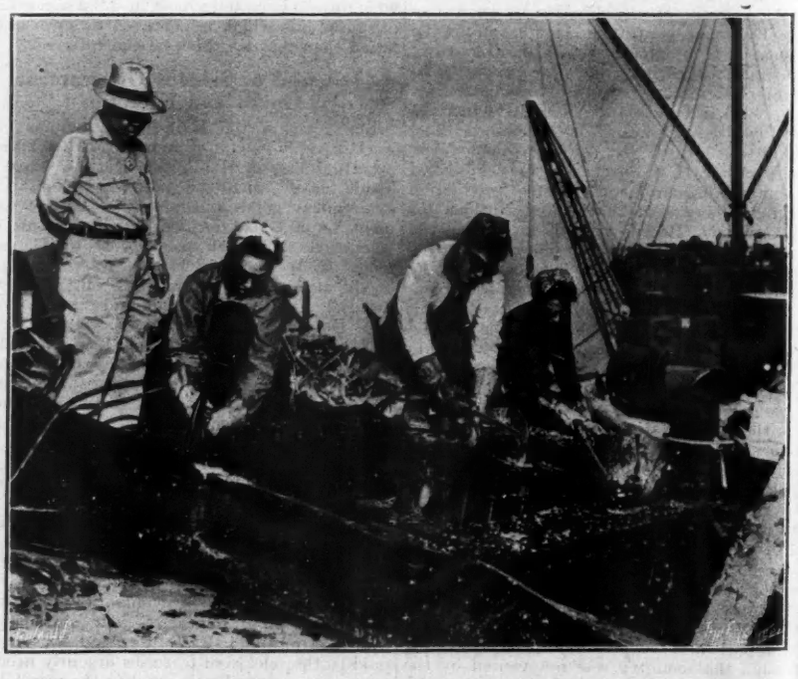
WITHIN seventeen months after the Japanese made their surprise attack, sixteen out of the nineteen ships damaged by that raid were salvaged or repaired and again ready for combat duty. A truly surprising record on the part of the responsible authorities and the whole-hearted collaboration given by everyone concerned at Pearl Harbour. This performance is a highly creditable one, because work on the ships that suffered by the Japanese raid was repeatedly halted or much slowed up in order to give priority to other ships of the Pacific Fleet which returned there for necessary repairs after actions in distant island sections of the south-western parts of that ocean.

DIVING OUTFIT FOR SHALLOW WATER WORK

Pearl Harbour, although well equipped to handle what might be termed ordinary wartime repair work on ships returning there for such service, was not quite ready to meet the intensified and even exaggerated demands such as suddenly confronted the Navy Yard immediately after the Japanese raid. Fortunately, that attack was almost exclusively directed against hangars, runways, aircraft on the ground, and the ships of the battle fleet; but relatively little damage was done to the machine shops, graving docks, and other plant at the station, and the first work was that of clearing up the shore installations to make ready to concentrate first on the repair of the unsunk ships and then to take in hand the longer and heavier job involved in refloating and refitting the ships that had been sent to the bottom. Haste in making indispensable repairs was the first consideration. The urgency of this was due to the fact that the defenders of Pearl Harbour, greatly reduced in their available resources, did not know how far the Japanese were aware of the effectiveness of their raid. For the nonce, the Island of Oahu was largely defenceless, and there was reasonable apprehension that the main battle fleet of Japan might arrive to take advantage of the situation—in other words, gain possession of the island. Therefore, the last of the enemy aircraft had scarcely disappeared over the horizon before the force at the Navy Yard was supplemented by the organisations of the contractors with their large and diversified resources of construction equipment, and by the prompt and splendid response of the civilians of Honolulu and the vicinity. Under able leadership, all hands pitched in, and in many instances worked the twenty-four hours around, not only for a few days, but for many weeks following the raid. Just as men and women are now engaged in America's shipyards, so men and women work side by side at Pearl Harbour. The unity of their efforts and purpose bore fruit in the speedy manner in which initial confusion was dispelled, and unflagging efforts became steadied upon the many-sided operations that brought about expeditious and astonishing performances in refitting many of the ships for any duty that might be assigned them. Specialists and urgent supplies were flown from the United States to Pearl Harbour, and equipment of many sorts was moved by fast vessels from the West Coast to aid in meeting the varied requirements of the hour. Momentarily stunning as the Japanese blow was, the immediate recovery and the determination to be ready for anything that might follow constitutes a magnificent example of co-operation on the part of people of many racial strains giving of their best in a common cause.

The battleship "Arizona," which was blasted in two and sent to the bottom by the explosion of her forward magazines, while a total loss as a ship, has, nevertheless, not been a total loss, because of the salvage of much of her steel structure, many of her guns of all calibres, and some of her machinery which can be used again. Even powder recovered from her after magazines has been or will be made again issuable when reworked. Divers, either in the regulation naval diving dress or in diving apparatus, consisting mainly of a soft rubber headgear, with an airline attached, have done excellent salvage work, either in deep water or in those parts of the wreck that lie at shallow depths. Submarine metal-cutting torches of both oxy-electric and oxy-hydrogen types have made it possible to do many difficult jobs under water and to do them with dispatch, and oxy-acetylene cutting torches, in the hands of men and women, have contributed handsomely to the almost endless tasks of cutting through armour plate, heavy steel members, and lighter structural parts above water or ashore.

Rear-Admiral William R. Furlong, U.S.N., Commandant of the Navy Yard at Pearl Harbour, has thus summed up what was required following the raid:—"You need all kinds of people for salvage. You must have divers, burners, mechanics who can work in diving suits under water, pumpers, electricians, and labourers. Once the ships are



CUTTING UP AND PREPARING SCRAP

floated, you have all types of artisans who more or less rebuild the ship. The salvage—raising and patching—is the spectacular part. We needed boats, barges, pumps, and a great variety of special kinds of materials. We had some difficulties, particularly in getting the special kinds of pumps and hoses." All these things were obtained as rapidly as possible, and what has been accomplished at Pearl Harbour has made that naval base far better now to meet any wartime development than it was early in December of 1941. The engineers of the Navy and the engineers of civil life, craftsmen of many sorts, and skilled and unskilled labour have given of their best in making the record established at Pearl Harbour.

The one regrettable outcome of the Japanese raid was the toll in casualties among the personnel of the Army and the Navy. The Army casualties were 226 officers and enlisted men, who were killed or later died of their wounds, and 396 wounded, most of whom recovered and were returned to duty. Among the officers and men of the Navy and Marine Corps, 2117 were killed, 960 were reported missing, and 876 were wounded but survived. The heaviest casualty list was that of the blasted and sunk "Arizona," which suffered the loss in killed and missing of 1071 of her personnel.

The salvage work at Pearl Harbour cannot properly be compared with the kindred operations carried out so successfully in reclaiming the German battle fleet in the waters of Scapa Flow. This is mentioned only because the two undertakings have been referred to as more or less comparable. The ships at Scapa Flow were sent to the bottom in exposed waters deeper than those at Pearl Harbour; the stricken craft sunk in the Hawaiian land-locked haven were sheltered from the hampering effects of storms, and the tidal range was a decidedly limited one. Work on the sunken ships at Pearl Harbour was, however, made especially difficult to deal with owing to the fact that they had suffered not only from bombs, but also from torpedoes launched against them during a raid carefully planned and carried out with the ferocity of fanaticism. The damaged structures were so ripped and mangled that the divers had to make their examinations and preparations for salvage with the utmost care and deliberation to avoid grave consequences, and when those preliminaries were finished the patching that remained to be done was both extensive and tedious. There was, besides, the demand for all possible haste to make at least some of the capital ships fit again to meet the foe should he return in greater force.

The illustrations in this article are reproductions of official U.S. Navy photographs.

Engineers and National Planning*

By DAVID ANDERSON, LL.D., B.Sc.

No. II—*(Continued from page 368, November 5th)*

A Programme of Planning

WITH these preliminary remarks in mind, a programme of planning might deal with the following matters:—

(1) Rebuilding of towns, &c., damaged by war.

(2) Home and Empire communications by
- Air,
- Steamer,
- Railways,
- Roads,
- Wireless,
- Telegraphs,
- Telephones.

(3) Distribution of labour;
- Siting of industry;
- Labour's share in industry;
- Emigration.

(4) Handling and distribution of food;
- Storage, refrigeration, &c.;
- Cutting out of middlemen and "parasites";
- Destruction of pests;
- Elimination of losses of food.

(5) Matters relating to the Services, both in peace and war;
- Naval;
- Military;
- Air.

(6) The Merchant Service, both in peace and war.

(7) Husbanding of natural resources;
- Coal;
- Oil;
- Timber;
- Cotton;
- Rubber;
- Rare metals.

(8) Chemical engineering.

(9) Research.

Although this is a long list, it does not cover agriculture, health, education, and other matters with which engineers have to deal, though perhaps somewhat indirectly.

Dealing with this programme in detail, it will soon be evident that the engineer has a great part to play in both its planning and execution.

(1) The scale of the task involved in the rebuilding of towns, &c., damaged by the war, can be judged from the fact that a rough estimate of cost amounts to £800 million. This may or may not be correct, and a great deal, some £125 million, has been spent already on repair work. The problem is a large one, and architects and engineers, town planners, and experts of all kinds will have to steer a middle course between the one extreme of merely reproducing past mistakes and drabnesses, and the other of monotonous pretentious layouts as seen on a drawing board. We want warm, living homes and towns, individualistic, characteristic of our climate, built with a wide range of materials and outline, but not architectural temples at one end of the scale and mere kennels at the other.

(2) The subject of home and empire communications is also a very large one. The surface of our Empire measures 14 million square miles, scattered over a global area of 196 million square miles, of which 141 million square miles is sea. In one way or other the linking together of our Empire and the means of transport is (apart from finance) entirely an engineering matter. Political considerations may unfortunately enter into the question of air lines, but it is greatly to be hoped that these may be reduced to the absolute minimum and that the only restrictions adopted may be such as are necessary to enhance safety and prevent collisions. A great deal of work has also to be done in Great Britain, small in area though it is, and already highly developed.

(3) As regards siting of industry, the distribution of labour, and other problems in connection therewith, the engineer's functions are not so directly concerned; but in view of his intimate contact with labour his views and experience are bound to be of assistance. If only on the human side his realisation of the cramping effect of modern machinery and methods may help him to evolve methods leading to still further shortening of hours, and perhaps to some diversity of activities on the part of the worker, that may remove the deadly monotony of some industrial operations and bring back the ancient pride of craftsmanship and interest in one's work. This may be dismissed as an idle dream by many, but those of us who can look back to early days in our apprenticeship will, no doubt, recall the difference made in mental outlook and happiness by some change or alteration in one's work.

(4) The handling, distribution, and losses of food open up a wide field for the engineer. Quite apart from the engineering details of the actual handling, storage, and refrigeration, &c., and the means of transport, there is the wide question of unnecessary movements. We are all familiar with the many stories about fish travelling from Aberdeen to London and back again before being sold; also of perishable fruits, vegetables, and other foods being destroyed because they cannot be gathered, marketed, and distributed at a reasonable price. It is estimated that about £1500 million is spent in Great Britain annually on food. Even if only 5 per cent. were saved, that is, about £75 million, this would be a useful sum for expenditure in other directions. As regards pests, surely the medical and engineering professions between them should be able utterly to stamp out rats and prevent a loss estimated at £60 million per annum for that pest alone.

(5) When one turns to naval, military, and air matters, both in peace and war, one realises that a tremendous problem has to be dealt with and that many other considerations than those of a purely engineering nature arise. And yet, as has already been pointed out, modern warfare is very largely a matter of applied engineering. The arming, servicing, supply, transport, protection, feeding, watering, fuelling, and many other matters in connection with all three Services are almost exclusively engineering operations. To say this is not to detract one whit from the skill and genius with which these engineering services are directed, and the valour and endurance of the fighting men who use them. It would, however, appear that engineers are not in the position that they ought to be as regards the planning and the foresight required both in peace and war, in connection with means of defence and powers of attack. It has been truly said that Great Britain is too apt to enter upon a war with the weapons and outlook of the war before. An engineering outlook, and engineering foresight, badly need to be engrafted into our war machine.

(6) The Merchant Service, whether in peace or war, is one of the lifelines of the country, as well as a source of income. It has grown and developed entirely on its own, with but few Government restrictions. For many years it has had to face subsidised competition from other nations while itself unprotected. Matters have reached such a pass that the statement was made recently—and not contradicted—that the coastwise shipping of this country was largely in alien hands. In certain districts of the world our shipping has been driven out by unfair competition. These things ought not to be, and some planned arrangements would appear to be necessary. This is not primarily an engineering matter, but engineering details arise,

* Institution of Civil Engineers. Presidential Address, November 2nd. Abstract.

especially in connection with the most economical running of shipping. For instance, in regard to speed—to which much reference has been made in connection with convoys—has there been any planned study and, if need be, research on the whole question of speed, not only actual travelling speed measured in knots, but also speed of loading and unloading, and more general questions, such as terminal facilities and delays?

(7) How do we stand as regards the husbanding of natural resources? Can it be said that there is any planned Empire policy regarding such wasting assets as coal, oil, timber, and even recurring crops such as cotton and rubber. The seriousness of this as regards coal may be judged from the fact that statements have been made that the economical winning of coal in Great Britain can continue only for another 200 years. One point in the Atlantic Charter is that all States should have access to the raw materials of the world. But it is doubtful whether anyone has studied how long the raw materials of the world will last. Less wasteful use of them badly requires investigation. This is a vast subject, calling for study and foresight. The engineering aspects are many. One alone might be referred to, namely, the poor efficiency (somewhere about 25 per cent.) of our present methods of obtaining heat from coal. Such sources of power as the tides, the sun, and the wind are largely untouched, although many of the difficulties that formerly existed have largely disappeared now that electric distribution of power has been so far developed.

On a comparatively small scale the Electricity Commission is an example of planning. Electricity undertakings now dovetail into each other and render mutual assistance, with results beneficial to the whole country. It is sincerely to be hoped that the newly set up Hydro-Electric Development Board for Scotland will now lead to an orderly development of the water power resources of the Highlands, and that schemes will no longer be subjected to the vicissitudes arising from the loud-voiced opposition of deer and grouse, not to mention the perhaps less vocal, but nevertheless formidable, opposition of that lord and master, the salmon.

(8) Chemical engineering is probably only in its infancy. This may seem to be an inaccurate statement in view of the great progress that has been made. Plastics and substitute materials, to mention only two fairly recent developments, have such wide possibilities that it is difficult to envisage what might result from them. The conversion of coal into oil and the fixation of atmospheric nitrogen into materials used as fertilisers, dyes, &c., are other outstanding matters. In America such keen interest exists in this branch of engineering that students taking chemical engineering at the universities outnumber those entering on other courses.

(9) As a last item in this programme of planning, a few words may be said in connection with research. Sir Isaac Newton declared: "To myself I seem to have been only a boy playing on the sea shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." Our horizons have widened since Sir Isaac uttered those words some 250 years ago. It can quite fairly be said that if he felt that he stood on the shore of a great ocean of truth, we nowadays stand on the brink of an ocean which daily seems to become more and more vast. In every branch of engineering research is being more widely extended. Some indications have already been given in this address of lines upon which more research is required. To attempt to plan or forecast research within the limits of time at my disposal would be futile. The whole realm of Nature, both visible and invisible, is at our feet. It is a work with which engineers should be very intimately connected, and one upon which they can exercise a steadying influence by keeping it on sound and practical lines and not allowing it to stray into unprofitable by-paths. Speakers at the Conference on "Civil Engineers and the Building Industry," held at the Institution in 1942, emphasised the importance of research, not only along the normal lines of study of materials, but also through the whole range of prescribing their use to the best advantage in design and construction and on to practical work at the site of the job.

How is This Programme of Planning to be Brought About?

It may be said that all this is too visionary. I hope that it is at least provocative of thought. To stand still is to stagnate. I realise that the ideas and suggestions set out in this address are far-reaching and are likely to take years to bring to pass. They are simply rough ideas, but they envisage a planned and scientifically managed country and Empire. I should like to suggest that in our own Institution we might resume informal meetings and discuss these matters. If, after study and discussion, they are found to be useful, then practical results may perhaps follow, but both people and Government will have to be shown their advisability. There is a natural hesitation in introducing changes into our professional outlook, and especially changes that impinge upon our national life. But if our profession and our national life are living organisms subject to growth and decay, it is only right that growth should be encouraged and that methods and activities that have outlived their usefulness should be abandoned.

Many of the matters touched upon in this address may be said to be outside direct action by the Institution; we shall be told to mind our own business. That objection must be risked, along with others that inevitably arise whenever changes are proposed, especially if they are of a far-reaching nature. The Institution, through its members and in various indirect ways, can create an atmosphere and sow ideas that will gradually bring about the changes desired. But active steps can also be taken by getting into still closer touch with our sister institutions and with the engineering industry generally, with a view to planning, leadership, and forward policies. It will, no doubt, be said that the various industries concerned are much better equipped to plan ahead and have a much more intimate knowledge of their particular business than the technical institutions can have. The force of this line of argument has to be admitted, but each industry is very apt to be swayed by its own particular interests and it may well be that wider views can be set forth by disinterested bodies such as the institutions.

A Joint Planning Centre might be set up. If it is at all possible to secure for it the goodwill and cognisance of the various Ministries, especially that of planning, the friendly contacts thus made should be very helpful and antagonisms kept out. This Joint Planning Centre could forthwith study the matters referred to in the programme outlined above, together with many others that would naturally arise. There is no need to wait for Government action. Governments are fettered in many ways that do not apply to professional institutions. Let us get on with the job ourselves. Public opinion can be educated by lectures, articles, books, and broadcasting, and this is essentially a matter to be directed by the institutions. In addition, and this has been referred to before, some joint action might be taken with the other institutions for direct representation in Parliament. If that is quite outside practical politics, the universities and colleges could be approached with a view to their pressing for a greatly increased representation in Parliament. Those representatives might well be engineers or, at any rate, men having scientific training.

Engineers and the British Empire

By Professor MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

No. XIX—*(Continued from page 362, November 5th)*

South Africa

THE record of British engineers in "the dark continent" resembles, in some respects, the story of their triumphs in other portions of the Overseas Empire. There was the same experience of dangers and hardships, the same exhibition of courage, endurance, and technical ability. But the physical characteristics of the country, the large number of uncivilised natives (most of them in savage and warrior tribes), the herds of wild beasts, the numerous disease-carrying insects, and, in places, the dense jungle, made the environment in which they worked very different from that found by engineers in Canada and Australia.

The great contribution that South Africa has made to the new world civilisation, in comparatively recent years, has been the large supply of valuable minerals needed to increase mechanisation and other engineering works. The first important development was in 1867, when diamonds were discovered, followed by the discovery of gold, copper, &c.

Slowly white men penetrated, during the last five hundred years, from the coast into the dark interior. The legends of the ancient gold mines in Ophir stirred the King of Portugal, in the fifteenth century, to send a great expedition to Sofala and inland to unknown territories. He instructed them to determine, once and for all, the truth of the legends that told of gold found in Africa for the throne of King Solomon, and used for his three hundred great shields of beaten gold. It was the lure of gold that first attracted adventurers into the country.

Portugal's most famous soldier, Barreto, was sent to capture the legendary gold mines for his King nearly five centuries ago. The great expedition failed in its object; it secured some unimportant trading rights and a few grains of gold, but hundreds of the best soldiers were killed by black warriors and deadly disease. It did, however, lead the Portuguese to acquire, later, much valuable territory in South Africa.

Travellers arriving in the mechanised vessels of to-day, who enter the mysterious

and little-changed port of Mozambique, may think of the tragedy of the brave Barreto and his gallant followers, struggling under savage attacks through the hot and humid jungle, in mail armour, seeking elusive gold. Some may remember that Assyrian, Babylonian, Indian, and perhaps even Chinese gold seekers, many centuries earlier, had landed at Mozambique. They can see, some 400 miles north of the largest goldfield in the world that has been developed (the Rand mines), the ruins, in Mashonaland, Southern Rhodesia, of Great Zimbabwe, where the miners of antiquity extracted, it is believed, gold worth £150 million; it was sent to destinations whose places on the map we can only guess. Some of those ancient miners may have been Phœnicians; they were clever engineers, for the traces of their work at Zimbabwe prove their technical ability.

Strange that the invaders of 3000 years ago into Southern Africa found gold, and that in the days of mechanised power it has been gold that has brought prosperity to South Africa. Strange that the almost impenetrable interior of the continent should supply the gold urgently needed for a world economy, enormously expanded by mechanised power, and provide world industry with copper, coal, and other minerals that suddenly came to be in great demand. Even diamonds found there were needed by engineers to speed up mechanised production. British engineers have already recovered many minerals of great value from Africa in less than a century; the dark interior may yet yield for mankind much more mineral wealth.

The earlier gold-seekers from Portugal failed in their quest for gold, but they blazed the trail for their countrymen, who, in Portuguese East Africa, now control 261,700 square miles of territory, believed to be exceedingly rich in undeveloped minerals and with great possibilities of agricultural development. With a coast line of 1000 miles it is the eastern gateway to Rhodesia and the Transvaal. It has some of the best harbours on the African coast, one of which (Beira) has been modernised by British engineers and British capital.

British Enterprise

Although for most of the nineteenth century (the days of the gradual increase in the use of mechanised power) British engineers were concerned almost entirely with the four provinces that now form the Union of South Africa, yet Livingstone, Stanley, Williams, and other intrepid British pioneers were penetrating further north, but south of the Equator, into "darkest Africa." They returned to arouse the indignation of their countrymen by their tales of Arab slave raiders; it was the urge to stop that infamous traffic that finally brought parts of Africa into the British Empire.

British enterprise and engineering ability profoundly affected the old Portuguese Colonies, the more modern Belgian Congo Free State, the Rhodesias, and the lands and natives yet further north. There was a time when all this territory in Southern Africa could easily have been incorporated in the British Empire, but Whitehall hesitated. In those days there were influential politicians who opposed any extension of the area of the Empire.

While, later on, the Chancellories in Europe were concerned with dividing up the vast continent of Africa into preserves for their own advantage, engineers were pushing forward steel rails through the deserts, the swamps, and the jungle, thus connecting remote districts, eliminating tribal warfare, cannibalism, and terrors due to superstition. In many parts of Africa, from Egypt to the Cape, British engineers, by their practical work, saved millions of natives from starvation and fear of sudden death. They have been the major factor in the development of the natural resources of the continent, by the introduction of power for transport, mining, and other purposes. Yet, as we look over the map, as we realise the size of the great rivers, the lakes, and the mountains, we must believe that only the prologue of the story of the transformation of Africa by means of applied science has been written.

Progress Continues

We cannot foreshadow the political future of the various parts of the vast continent, but the intrigues of selfish and wicked men succeed only for a period; they never, in the end, prevent the onward rush of the new knowledge that transforms the desert and the jungle, and even the savage, into agents that increase the production of food and goods needed to improve the standard of life for humans, not only in "darkest Africa," but all over the world.

From the Cape to the Congo there are enormous areas in which geological formations are found wherein useful, probably valuable, minerals may be discovered at any date; in fact, new mines are in this era often developed. But if the rapid economic development of this sub-continent is to take place, the engineer must be supported by statesmen with a wide vision. That must embrace not only the four provinces of the Union, but the mandated territory of South-West Africa, the protectorates of Bechuanaland, Basutoland and Swaziland, the two Rhodesias, and even—with qualifications—the non-British territories of Angola, Mozambique, and the Belgian Congo. For the efficient production of the vast natural resources, the whole of Africa, south of the equatorial zone, must be brought into economic co-operation, even although political amalgamation with the Portuguese and Belgian provinces is impossible. The Union can play a great part in building up a new and prosperous South Africa, which will give scope for local loyalties, but will consider, above all, the prosperity of the whole great area.

Experienced engineers believe in the possibility of Southern Africa leading the world, for many generations, in the production of gold, copper, and probably coal, and, in addition, supplying other rarer minerals needed by mechanised civilisation. Already it has absorbed vast quantities of machinery made in the workshops of Britain, and more will be needed. In spite of the tremendous efforts, stimulated by the war, to increase industrial production of all types in the Union, there will remain, for many years, an important market for engineering equipment in Southern Africa.

The Union of South Africa

When the intrepid navigators of the fifteenth century slowly explored the oceans beyond Europe, one of their earliest triumphs was rounding the Cape of Good Hope. At the southern end of Africa it lies almost exactly halfway between Europe and India. The Portuguese reached it first; then two English captains landed and claimed the territory for England (1620), as was then the way of English captains; but no one in England took any notice of their claim. So the Dutch, who first appreciated the importance of the Cape for ships on the way to India, settled there (1652) and retained this strategic point for 150 years, until the British came into possession (1806) during the Napoleonic wars.

For all practical purposes it was the Dutch and the British who settled in this part of the world and made homes, although other nationals, in much smaller numbers, were also attracted to stay there. Towards the end of the nineteenth century the Germans founded a colony in South-West Africa, but they were harsh colonists and the native inhabitants were very pleased when, in 1919, they came under the protection of the British Empire.

In spite of the hopes of the early settlers, only meagre wealth came from the poor soil of the hinterland of the Cape. Slowly the Dutch penetrated to the interior plateau, where they found the conditions more favourable than those that harassed the early colonists elsewhere; there were not the biting cold and fevers that afflicted Canadian pioneers, nor the hunger and thirst that injured Australian explorers, but air that gave white men keenness in youth and strength in old age. For the interior lands are from 1000ft. to 6000ft. above sea level, and altitude compensates for latitude. But much of the land was unproductive; the best areas were densely populated by natives and that led to many conflicts. The standard of life of the settlers fell below that of white pioneers in other parts of the world. The economic and racial problems of the country were made difficult because of its poverty. Finally, South Africa gained its wealth and high position in the British Empire because of its minerals. It passed through many crises, political and economic, before it attained the status of a Dominion.

The Dutch selected Table Bay as a calling station, although it did not possess such a good natural harbour as Walfisch Bay, on the west coast, or Delagoa Bay, on the east coast; but there was water behind Cape Town and, unlike the other harbours, there was neither malaria nor the tsetse fly. They soon realised that it was the natural gateway for settlers into the promising inland plateau.

The Dutch colonists were content with a simple scale of living, so that when the British began to administer South Africa they found the country undeveloped and backward in enterprise, as compared with their own colonies. The engineer had not made his presence felt in this land of millions of natives and a few white settlers, living an isolated and patriarchal type of existence, behind Cape Town. There were then less than 25,000 colonists.

The British soon determined to change the old conditions. In 1808 about £125,000 were spent on public works, and Cape Town soon had the benefit of waterworks. But the Boers were unwilling to adapt themselves to a new age, where increasing populations needed more food, and machines required more raw materials. They trekked away from the inevitable industrial revolution, only to find that it had suddenly appeared in the midst of their patriarchal society, when diamonds were found in Kimberley (1869). That was the beginning of industrial activity in South Africa. It was perhaps a bad beginning, for, like all sudden rushes for quickly won wealth, as in California and Australia, the lure of an easy fortune drew many adventurers. This time they came into the neighbourhood of others whose lives were rigidly moulded on the Old Testament. Soon there were more other-whites in Kimberley than the Boers who had taken part in the Great Trek. That caused, once again, the age-old conflict between men with opposing ideals. It was complicated by the disruption of tribal life, for natives worked on the mines, and thus commenced to form the urban proletariat in South Africa.

Diamonds soon attracted capital which had previously been difficult to obtain. Miles of railways were rapidly laid inland from Cape Town, Port Elizabeth, East

London, and Durban, in order to transport machinery and necessities for the mining community. Gradually individuals, digging up gravel, and moving it to water to sift it, gave place to organisation. Cecil Rhodes afterwards won fame, with its accompanying hero worship and hatred, as South Africa's dominant personality in politics, but he first revealed his genius for organisation and planning, on a big scale, when he amalgamated all diamond mining interests into the famous De Beers concern. It may be true that there are sordid as well as gallant episodes in that story of the triumph of a country parson's son over many enemies, including such formidable opponents as an East End Jew, a French diamond merchant, and a German rival, but no one could compare with Rhodes for the brilliance of imagination, the tenacity of purpose, and the daring of action that ensured his success. Posterity will judge his methods less critically than many of his contemporaries, for time has proved that in the end his chief ambition was to benefit South Africa and the British Empire, and to organise material progress which, he believed, could be done more rapidly by the British than any other people.

Diamond mining provided the incentive and the means for mechanisation of transport and industry; it provided much more money for salaries and wages. It saved the Cape from catastrophe when, in 1869, the Suez Canal diverted shipping from Cape Town. Capital, which was difficult to obtain at 6 per cent. before 1870, was soon afterwards available at 4 per cent. Engineers know that cheap money stimulates the development of natural resources and industries.

By 1886 the Colony had spent £14 million in building 1000 miles of railway, although in 1870 only 69 miles had been constructed. Mineral developments were drawing South Africa into world economy and the search for raw materials had led the whole continent into the whirlpool of European diplomacy. The struggle between the old and the new, between the ox wagon and mechanised transport, between the use of primitive tools and engineering science—that went on, with the added complications of old political and racial antipathies.

Then came the discovery, in 1886, of the greatest gold mines in history. From that date an unprecedented development in mining, near Johannesburg, made the eyes of the civilised world turn to South Africa, and gold became the most important asset of that land.

The story of the clashes between the mine-owners and the old *régime*, the labour problems, and the fight to keep the railways within territory that is now incorporated in the Union; the tragedy of war, the decision of the Dominion to fight against German aggression in 1914 and in 1939—all those events are part of the mosaic of world history that includes many episodes, some splendid, others that reveal the stupidity and ignorance of men in authority. But the mines financed the new mechanised civilisation, which made progress, even in the difficult problem of improving agriculture in South Africa. For the low rainfall in places made farmers demand irrigation.

The Mining Industry

From the gold mines of South Africa there was extracted, in fifty years, three-quarters of all the gold produced in the whole world during the four preceding centuries. The gold strikes in California, Australia, and the Yukon resulted in output that could not compare with that of the Witwatersrand. It was known, long before the modern rush began, that there was gold in the Transvaal, but no great nuggets rewarded the men who had been digging with but little return for their labour, until the deeper deposits on the Rand were discovered. The gold there was not easy to obtain. A new technique in mining soon had to be evolved, when the gold near the surface had been creamed off.

The gold-bearing reefs dip down obliquely to great depths, so that some of the miners now descend to over 8000ft. below the surface. These reefs cover an area 170 miles by 100 miles. The mines are the richest in the world, because they seem to be inexhaustible; but they are also the poorest because the average gold content per ton of ore is so low. The researches and inventions of chemists and engineers made profits possible when the poor ore was extracted. Nor must we forget the revolution in financial organisation that made available large sums of money needed for machinery and its transport.

The machinery, without which the gold could not be recovered, needed power to drive it. Coal was found, abundantly, near the mines; it proved as valuable for gold as it had done for iron and steel in earlier times in England. Moreover, diamond mining had provided men of experience in local conditions and with money ready for use in the new industry. Within a few months of the discovery of gold, on the Rand, mining had developed on an important scale. There were sudden fortunes and many losses in the early days, but—as was the case with diamond mining—it became imperative to substitute a few highly organised companies for the numerous small and competitive concerns that could not afford to pay for expensive machinery, and the best expert advice in the world. Once again the genius of Rhodes brought order out of chaos; within six years he had brought into existence the Consolidated Gold Fields of South Africa.

The news of the gold mines attracted men from all over the world, but the majority were British, although many expert mining engineers were Americans. The rush of immigrants, and the mechanisation introduced by the new industry, created far greater changes than had been the case with diamond mining.

Mechanisation Resisted

The most stagnant of the areas colonised by Europeans suddenly became the centre of intense activity. In twelve years the Transvaal Government had a revenue twenty-five times greater than in 1883. In 1896 the export of gold from the Transvaal was 97 per cent. of the total exports. Cape Colony and Natal also reaped great financial benefits. Capital, and the new mechanised civilisation, had overtaken the ox wagon, and the descendants of the Boers of the Great Trek; men of enterprise became impatient with the antiquated ideas of the farmers of the veld. The newcomers, with their money and machinery, demanded innovations and security for their investments, often in a vigorous and aggressive fashion, that shocked the slow pride of the Boer community, who valued above gold their old social and spiritual traditions. An industry that affected the markets of the world could not easily tolerate the local outlook of men dependent on land and cattle. Britain was then unpopular both in Germany and France, because of her successful Colonial Empire. The diplomatic strategy of those countries alarmed the owners of the gold mines in the Transvaal. Meantime, the shafts went down deeper and deeper until they reached sea level.

More costly machinery was imported. Every ounce of gold had to be extracted by an expensive and scientifically developed process. Transportation on the narrow-gauge railways, which carried goods from the seaports to the high interior plateau, was expensive; the Cape Colony lines crossed over hundreds of miles of barren land. The mining magnates and British artisans and engineers did not disguise their contempt for and resentment against the economic and political inefficiency of the various Governments in South Africa; they knew it was a hard struggle to balance ledgers that were loaded with costs of concessions, taxes, and other items which they called "Government oppressions." Yet the remarkable work of engineers, scientists, and administrators enabled dividends to be paid. At times hopes for reforms were high; at times Kruger and his friends seemed willing to compromise. But the problems were too complex; some of the leading antagonists were perhaps too narrow-minded and prejudiced.

THE "RAND" GOLD MINING DISTRICT

An eminent American Professor of History has told us that "the book is yet to be written that will do full justice to the points in dispute." He writes: "The picture of the capitalists, as men with gold in their hands, brass in their tongues, contempt in their faces, and treachery in their hearts, is as untrue as the picture of an Empire robbing a petty state of independence out of envy for its wealth, or the picture of an ignorant and perverse old man leading his State into destruction rather than yield to a modern age." But the urge for reforms, made by men demanding efficiency in government and mechanism in industry, was also the concern of the Chancellories of Europe. It left behind bitter memories, that affected not only South Africa, but international relations. It helped to deflect the energies of engineers and scientists from works that raise the standard of life to the mechanism for war that produces economic disaster and death. But the Transvaal mines supplied gold when the world's demand for the metal, due to expanding industrial development, was in excess of the supply. They gave confidence all over the world that the old technique for currencies would not be upset by violent fluctuations in the supply of gold. Unfortunately, they created social and political problems that inevitably had to be solved at

some time; but perhaps those who tried to solve them were unaware of the tremendous changes that applied science had made in the organisation of world trade and industry. Most certainly the Boers did not understand that the spirit of British colonial policy was to ensure freedom rather than subjection. They failed to accept the British humanitarian ideas about the treatment of natives.

The technical triumph of the development of the Rand gold mines has been mainly the story of the struggle between applied scientists, the low-grade ore, and the increasing depth of the mines. Huge air conditioning plants were installed, but they are expensive; there is a rich reward for any engineer who can make air conditioning in the Rand mines more economical. In 1934 the largest air cooling plant in existence was installed in the Robinson Deep Mine; its performance is capable of producing the equivalent of 4 million pounds of ice daily. The use of compressed air in drills is valuable for cooling.

In several mines water is a problem of importance. It was stated in evidence before a Commission in 1931 that fourteen mines, with a combined profit of only £14,300 a month, had to bring to the surface 250 million gallons of water monthly. It is of interest that the dry air pumped into the mines returns to the surface with 70 per cent. humidity; this throughout the Rand accounts for 250 million gallons a year.

The Chairman of the Transvaal Chamber of Mines, five years ago, gave some interesting details of the gold mining industry. He said: "Under the stimulus of the enhanced price of gold the mining industry has pursued the even tenor of its way, so that the year 1937, like its immediate predecessors, was a year of progress and expansion." The ore crushed exceeded 50 million tons, yielding nearly 11·5 million fine ounces, which sold for just over £80·5 million—a record in quantity and value. The increase in revenue, however, was more than offset by an increase in cost, and working profits showed small decreases in the aggregate. The Chairman said that gold producers could act with confidence as gold "is the ultimate refuge in time of financial trouble." He added: "While it is sensible that the country should seek to develop other natural resources concurrently with its minerals, I suggest that it is fundamental to foster and encourage at all times the one industry that alone has made our national development possible and which alone can maintain our economic existence."

There are special arrangements for training white mining engineers and skilled miners in South Africa. The number of apprentices in the Government Miners' Training Schools, which confine their activities to turning out practical miners as distinct from engineers, increased from 1221 in 1937 to 1318 in 1938.

British factories have provided a great deal of machinery used in the mines of South Africa. One power company had installed, in 1938, electricity generating plant totalling 520,000 kW, and had under construction two other stations designed for a total addition of 720,000 kW. Further, it owned plant totalling 142,500 H.P. to supply compressed air.

Not long ago one firm sent out from Manchester five electric winders, three designed to wind from a depth of 6660ft. The most powerful of these machines had two motors, 5000–12,000 H.P., the winder running at 32·74 r.p.m. and working thirty-one winds per hour. This winder is installed at the Rand mines, the owners of which have also installed three winders for their Simmer and Jack Gold Mines. In this latter installation the mine shaft is arranged for three pairs of skips, the skips weighing 9000 lb. each, and the weight of rock lifted per skip is 16,000 lb. The steel ropes are 2in. diameter and have a factor of safety of 4·8. The drum of the winder makes 65·3 r.p.m. for a wind of 6660ft. The building housing the three winders and auxiliaries is 217ft. 6in. by 106ft. 9½in. The drums are built up from cast steel sections, there being no less than fifty-eight parts in each, secured by 550 fitted bolts. Each complete drum weighs 127 tons. This is a detail of mechanisation of one mine only; it gives us a glimpse of the power and machinery absorbed by mining on the Rand.

The Great Depth of the Mines

A visitor to a gold mine goes straight down a shaft 6200ft. deep. The ore skips do the journey down in two minutes, but humans go more slowly to adjust their breathing apparatus. The bottom of the mine is finally reached at a depth of 8500ft. Black and white men are sweating, drilling, and breaking up the ore that is to be carried to the surface for treatment. The rock temperature is 105 deg. Fah. and, in spite of big air conditioning machines, the atmosphere is uncomfortable. A director of the mine says that there are 500 miles of tunnels in it; he gives as a rough guess the length of the tunnels and passages down below, for all the Rand mines, as from 20,000 to 25,000 miles. How much deeper will they go to recover gold? The optimists say to 12,000ft., but it obviously depends on the cost of air conditioning, ventilation, pumping water, improvements in mine equipment, and the market price of gold. In 1939 Mr. R. Craib, consulting engineer, outlined a method of working down to 12,000ft., estimating that £30 million capital would be needed. Sir Robert Kotze and other mining engineers have said that mining down to 12,000ft. can be economically carried out.

On the surface you can see the equipment for the recovery of the precious metal from the mass of ore. There are stamp batteries, grinders for pulverising the ore, large cyanide tanks, reduction furnaces, and much other gear. They reckon to recover 93 per cent. of the gold in the ore.

Calculation shows that the mines of the Rand, having treated 1200 million tons of ore, have brought to the surface enough material to build a wall 68ft. high and 68ft. wide that would stretch from Johannesburg to Cape Town, a distance of 1000 miles. And yet the total amount of gold won from the mines would be sufficient only to make a solid cube measuring less than 28ft. each side.

As you move along the Rand you find other modern towns that men now living can remember as mining camps. One of them, Germiston, 9 miles from Johannesburg, is the sixth largest municipality in the Union. There are 327,000 natives, from various districts in South Africa and from Mozambique, working on the Rand—the tribal groups indulge in tribal dances for recreation! There are 40,000 white men working in connection with the mines. And fifty-six years ago the Rand was a vacant area!

It should be emphasised that the engineering development of the mines provided the money needed for numerous other engineering works. One result of immense value to Great Britain was the great demand for all types of machinery, much of which was produced in the workshops of this country.

(To be continued)

The Bristol "Hercules" Aero-Engine

IN an article which we published in our issue of December 5th, 1941, we described and illustrated the construction and assembly of the Bristol "Hercules III" aero-engine. Since that time further progress has been recorded in the development of this engine. It is now playing such an outstanding part in the air war against the Axis that it may be looked upon as one of the most powerful engines doing duty to-day with the Bomber Squadrons of the Royal Air Force. Since the first "Hercules" engine was introduced in 1936 continuous progress in

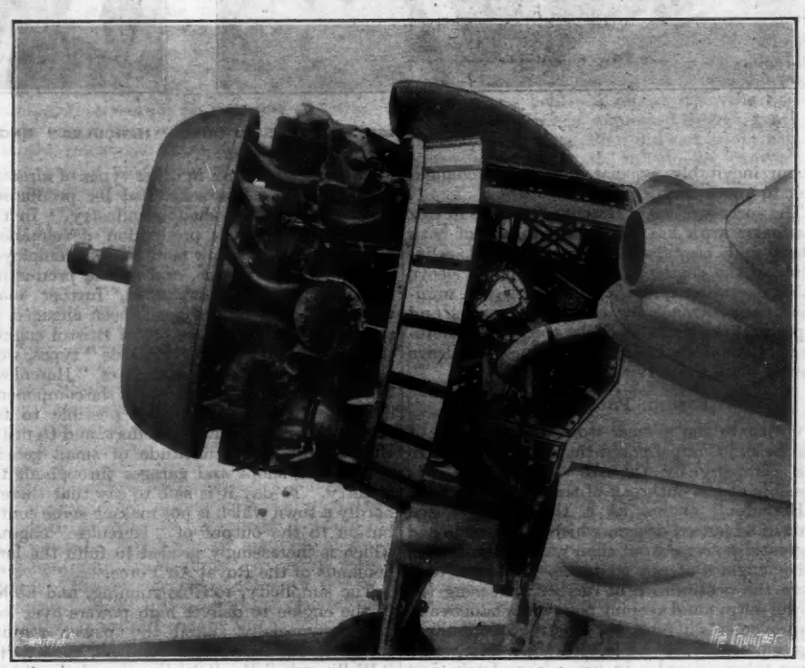


FIG. 1—ENGINE INSTALLED IN A "BEAUFIGHTER"

design has been made, and of the type of engine which is now being employed in such large numbers it may be stated that the maximum power output at operational height has been increased over the initial power by over 60 per cent. It can be also said that still further advances in power are in view, which are such as should keep this type of aircraft engine in the forefront for a considerable time to come.

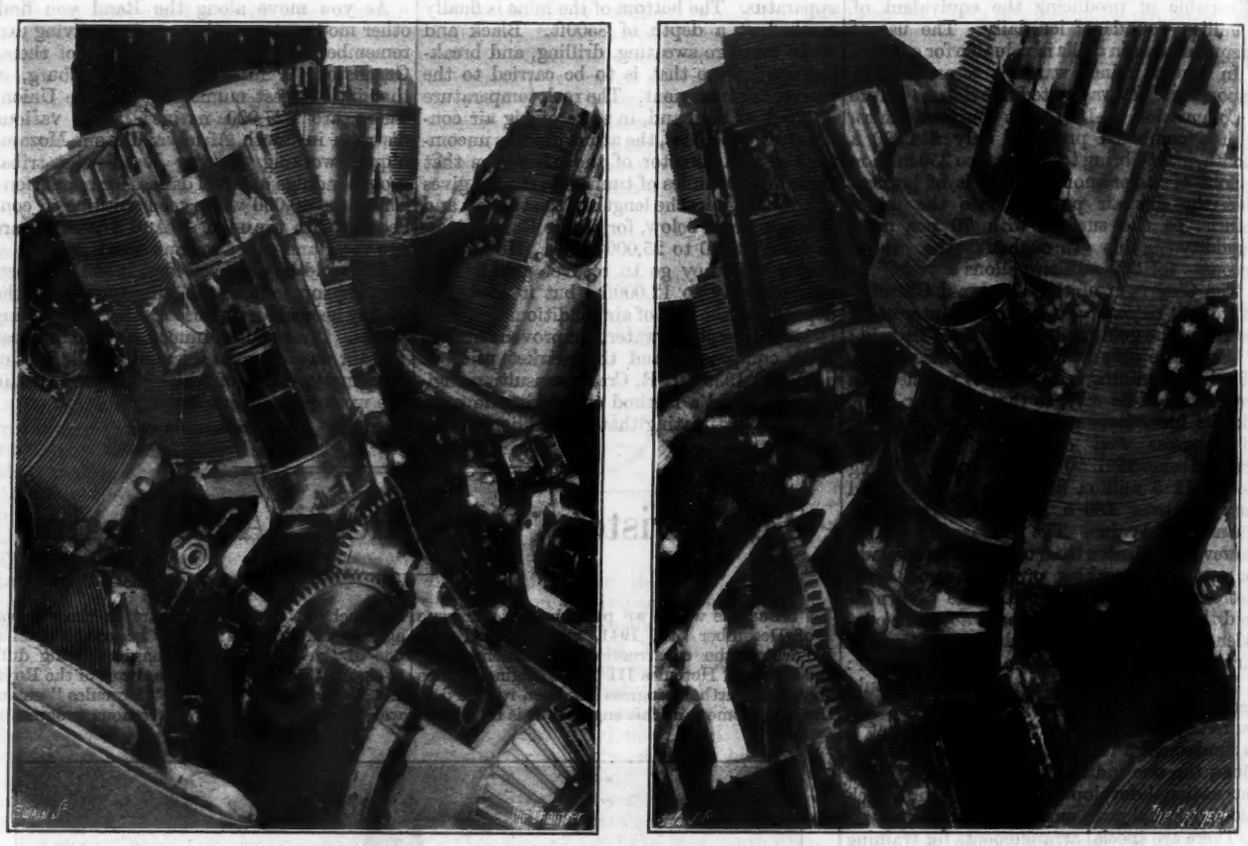
Two of the principal modern military aircraft in which the "Hercules" engine is installed are the "Lancaster II" heavy bomber and the "Beaufighter," which, with its four cannon and six machine guns, is still the most powerfully armed fighter in the world. In addition to these duties, the "Hercules" engine has been called upon to take its part in the no less important work of re-engining aircraft, which might otherwise have had to be withdrawn from production and active service, with that serious loss of machine tool power, materials, and labour inevitably associated with the change-over to another type of manufacture.

The success of the "Hercules" engine in this particular work has earned the regard of both pilots and crews. The fundamental reliability of the engine owing to its simple sleeve valve operation and its air cooling has minimised maintenance for the ground crews and supported the claim made by the Bristol Aeroplane Company, Ltd., that the use of sleeve valves simplifies service work.

Engine Production

Owing to the pioneer work and foresight of the Bristol Company and the support given to the company by the Air Ministry, it was possible at the outbreak of the war to offer the "Hercules" engine as a thoroughly tested unit of advanced design, which at the time had a greater power output than was available with other engines of proved types. Inherent to it were the possibilities of further increasing the power output and keeping pace with changes and improvements in fuels, both matters of outstanding importance, having in view the time it would have taken in order to get a completely new aero-engine into large-scale production. This mutual confidence of designers and users was shown by the decision of the Air Ministry in commissioning the Bristol Company to build, staff, equip, and manage a completely new factory which would be entirely devoted to the large-scale production of "Hercules" engines. This work was begun in 1941, and, despite the need for utilising local labour, which was largely female, often with an entire lack of precision engineering background, the first engine was finished before the end of that year. Since the beginning of 1942 the factory has come into its stride and has achieved a production which is some 60 per cent. in advance of that estimated. This performance the firm regards as a testimony to the efficiency of the parent company's organisation methods and the fundamental simplicity of the engine, both as regards its design and its detailed components. With the successful operation of the earlier "Hercules" engined machines, demands were made for its use in other types of aircraft, and the engine was scheduled for production by the aero-engine shadow industry. In the early stages of this production development other new main shadow factories were employed in building the engine, and as the production requirements were expanded, further main works, which had previously been engaged on the machining and assembly of Bristol engines of the "Mercury" and "Pegasus" types, were changed over to the building of "Hercules" engines. Again the simplicity of the components already referred to made it possible to tap further reserves of national effort, and to utilise the services of a multitude of small general engineering shops and garages throughout the country. To-day it is safe to say that there is hardly a town which is not making some contribution to the output of "Hercules" engines, which is increasingly needed to fulfil the large demands of the Royal Air Force.

The simplicity, reliable running, and ability of the engine to deliver high powers over long periods specially suited the power requirements of the long-range bombers, such as the "Wellington," the "Stirling," and the "Lancaster," in which the high take-off power of the engine enabled bigger bomb loads to be carried. While it is not possible to reveal official facts and figures, some indication of the good work done can be gathered from citations which accompany awards of honours, and the recurring fact of battle-damaged aircraft with one or more engines shot up being safely brought home, despite the heavy loading thereby imposed on the remaining power units. In the case of the "Beaufighter," which has been produced and engined in thousands, success has been attained whether that machine is a night fighter, a long-range day fighter, an intruder, or a high-speed bomber. More recently the "Beaufighter" has been equipped with special brakes for torpedo dropping. This machine, which we were recently permitted to see in flight, is now available for attacking enemy shipping in distant enemy waters and can speed or fight its way home through the fiercest opposition.



FIGS. 2 AND 3—SECTIONED "HERCULES" ENGINE

The present-day highly co-ordinated teamwork and technique of air operations favours simplicity and reliability, which is largely bound up with efficient service and maintenance. The "Hercules" engine has, we are informed, just over 7000 parts, but owing to the fact that several identical parts may be needed in one engine only 1000 different parts are required.

Engine Description

Three factors enter into the construction of this high-power aero-engine. They are the use of a radial construction, which permits the use of individual assemblies, which are simple to manufacture, handle, service, and replace; the use of air cooling, with the absence of difficulties and complications associated with secondary cooling; and the employment of the "Bristol" single-sleeve valve system of operation.

The engine we recently inspected in course of manufacture and assembly is the "Hercules XVII," which is higher in output than the "Hercules III" described in our December 5th article of 1941. The principal technical par-

ticulars and dimensions are given in the following table :—

Diameter of engine	52in.
Number of cylinders	14
Arrangement, two rows, each of	7
Diameter of cylinders	5¾in.
Piston stroke...	6¼in.
Cubic capacity	2360 cubic inches or 38·7 litres
Power developed, over	1650 B.H.P.
Economical cruising consumption	Less than ½ pint per B.H.P.-hour

For details of the engine and its assembly reference may be made to our last article, mentioned above. It may be recalled, however, that the two rows of seven cylinders are arranged radially around the forged crank case of light alloy, the rear row being staggered in relation to the front row. Adequate cylinder cooling by the deep close-pitched finning of the cylinder barrels and the use of a light alloy die-cast cylinder head with deep ribs is provided for. The design of these parts is clearly shown in the two views of a sectioned engine which are reproduced in Figs. 2 and 3. The two-throw crankshaft is built up in three sections, according to Bristol practice, and it has special torsional and flexural vibration eliminators. One piece connecting-rods are employed, which are attached

Fig. 4—Sectioned Air-Cooled Exhaust Ring

to the master rod by wrist pins. The steel sleeve has four specially shaped ports, to be seen in Figs. 2 and 3. It is drivenat half the engine speed by a simple arrangement of cranks and gears, and it is claimed to have a better gas inlet and discharge coefficient than the four poppet valves which in the earlier engines it replaced. The timing is simple and does not need adjustment. The piston is an aluminium alloy drop stamping with a flat crown. It carries gas rings of deep section, together with two oil scraper rings. The fully floating gudgeon pin is case-hardened and lapped. The generous ports of the sleeve valve and its well-planned motion enable the most to be made of the high-efficiency centrifugal type supercharger, which is built into the rear of the engine and driven from the back end of the crankshaft. It has two speeds. The low gear provides the maximum power required for take-off and the initial climb, and the high gear for the sustained power output at high operational altitudes.

All the essential engine accessories, such as the magnetos, and oil and petrol pumps, are arranged on the rear cover of the engine, and are driven from the main crankshaft. In addition, a power drive, which, through the medium of a gear-box, serves the many and various accessories which find a place in a modern aircraft, is provided. This special grouping of the auxiliary units and the power drive is claimed to give the aircraft designer greater freedom in the choosing of his accessories, while in service the maintenance of the engine and auxiliaries is simplified. The power developed by the engine is transmitted to the airscrew through a bevel type of epicyclic reduction gear, having a reduction ratio of 0·441. It is arranged concentrically with the crankshaft at the front of the engine, and provision is made for an airscrew of the constant-speed multi-blade type with hydromatic or electric control.

In Fig. 1 we show the "Hercules" engine installed in a "Beaufighter." The method of attaching the engine, is by means of a four-point suspension. Some other improvements connected with the exhaust system call for mention. Our illustrations indicate the very short exhaust pipes from the cylinders to the exhaust ring. That ring is cooled by the air stream, which is made to pass between the ring and the exhaust shroud. At the back of the engine there is a segmented ring, the elements of which are hinged at their bases and can move outwards by means of the operating chain controlled from the cockpit. By this means the amount of air passing through the engine may be varied. For engines installed in night fighters particular care is taken to disperse the hot gases and flame by means of auxiliary nozzles, grouped along the outer surface of the main exhaust outlet. From what has been said it will be appreciated that the power output of the "Hercules" engine has been advanced since we last described it, and improvements have been embodied in both the design and arrangement of the engine. We look forward to further applications and still further advances in design.

Visible Strain*

The diverse responses of a flowing fluid to variously shaped obstacles, such as a boat hull or a heating pipe, form a fascinating study, but not a very exact one, unless the directions of flow can be made visible. A new method of doing this, developed during recent years at the Massachusetts Institute of Technology, promises a real advance in this branch of hydrodynamics. The method is analogous to that wherein engineers use polarised light, produced with optical equipment similar to that in "Polaroid" non-glare sun glasses, to render visible the strains in plastic models of solid structures, such as gears. When stressed, the plastic model deforms slightly, and in so doing bends and twists the polarised light passing through it so that bands and splotches of colour show up at the points of strain. In the analysis of fluid flow a suspension of bentonite (a clay found abundantly in the West) in the fluid serves to modify the polarised light shining through the transparent walls of the experimental channel, just as the plastic modifies light in analysis of strains in solids.

The bentonite particles consist of platelets so small that there is no tendency to settle out of the suspension, and so light that they move exactly where the fluid takes them, showing substantially no inertia of their own. These physical factors, as well as its optical properties, make bentonite superior to other substances used to follow fluid flow, such as ink streams, smoke trails in gases, or fine bubbles; for these latter materials cannot follow the paths of fine eddy motion encountered when streamline flow is broken up. The bentonite for the first time permits quantitative measurement of velocity change and other factors within the field.

Solid plastic models examined with polarised light show infinitely varied coloured patterns when subjected to pressure or tension. A line of a given colour connects points where the strain is equal; from this the analyst can determine where the strains are concentrated and the model can be redesigned to put strength where it is needed and eliminate it where it is not needed. Similarly, in analysis of fluids, the bentonite so modifies the light passing through the stream that coloured bands or "fringes" show up, connecting points where a particular rate of change in the speed of the fluid prevails. Use of improved photographic techniques, including high-speed photography, has enabled observation of highly turbulent as well as more nearly streamline flow by this method.

The method can be used either qualitatively to observe how a moving or stationary object of particular shape affects the flow, or quantitively to calculate necessary engineering data. Analysis of fluid flow is important, not only in such obvious applications as design of boat hulls and bridge piers, but also in many chemical engineering problems, such as the distribution of fluids in a reaction vessel. It is even possible by polarisation analysis of fluid flow to calculate the rate at which heat will be transferred from a solid to a liquid.

Within limits, the information obtained with liquid flow is applicable to gases, so that the method becomes useful in aviation and many other fields. Although there has been time for only a few applications of polarisation analysis of fluid flow, one of these is providing graphic demonstrations for training aviators in flight theory. Another application has served to change the design of fire-boxes in the locomotives of a western railway.

* From *The Industrial Bulletin*, September, 1943.

The National Smoke Abatement Society

On Friday last, November 5th, delegates from local authorities all over the country, together with health and fuel experts, met at the first conference of the National Smoke Abatement Society to be held since the beginning of the war. Measures for ensuring the smokelessness of all post-war building schemes were fully discussed. They included provisions for at first halting and then abolishing the smoke problem, which, it was pointed out, is now over 600 years old. The proposals made include a demand that all new fuel-burning plant should be approved for suitability and smokelessness before it is installed, a practice which has already been followed by good results in America and elsewhere. It is also suggested that all new housing should be equipped with modern smokeless fuel-burning appliances only, with not more than one open fire, which, it is stipulated, must be smokeless. Central areas in all the larger towns should, it is suggested, be scheduled as smokeless zones, and at a later date a "Ten-Year Plan" would be put into force, which would have the effect of gradually extending these first smokeless zones until they covered the whole town or city. At the morning meeting Sir Lawrence Chubb took the chair, and an address was given by Mr. Clough Williams-Ellis, F.R.I.B.A., on "The Purpose of Planning and of Clean Air." Mr. E. H. Keeling, the Chairman of the Greater London Advisory Council for Smoke Abatement, took the chair at the afternoon session, when a general discussion was held. A report from the Society to the conference expressed regret that the County of London Plan did not adopt a more courageous attitude to smoke prevention. The report also makes reference to the part which smoke prevention can play in directly aiding the war effort. The smoke abatement officers of local authorities can do, it says, a great deal to assist the campaign for fuel economy. Not only can fuel be saved, but every reduction in smoke, it is pointed out, leads to healthier, brighter, and cleaner conditions in our industrial towns, upon the vitality of which our offensive power so largely depends.

Beneficiation of Iron Ore.—Beneficiation is a new American word coined by the United States Department of the Interior, Bureau of Mines. This term is applied to iron ores that have been concentrated by washing, jigging, and magnetic and high-density separation to remove gangue and other impurities. Fine ores are agglomerated by sintering into lumps, which form a material suitable for feeding to the furnaces in that it is porous and does not tend to choke the draught. Sintering also has the great advantage of removing most of the sulphur and moisture contents. During the year 1942 some 49,936,613 tons of crude ore were treated by this process for the production of 25,917,959 short tons of "beneficiated" ore.

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CHANGES OF ADDRESS

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AFTERWARDS

As the war, "like a wounded snake, drags its slow length along," ever drawing nearer to its predestined end, the outline of the pattern of the new England which men seek to build becomes sharper. The hazy ideas of a year or two ago, ideas which foresaw an England wholly unlike that which so many millions through so many centuries have loved so well, are slowly being overborne by the counsel of those who would salve from the past all that is inherently good and blend with it, or weld on to it, those new things that an advancing culture requires. There is less talk now of revolutionary changes and more of rebuilding on the old foundations a finer edifice. During the long months of bitter struggle the more responsible people devoted all their thoughts and energies to a single purpose, the winning of the war. They left to others less weighted with heavy duties the detailed discussion of the post-war world. Keeping before them a few broad principles as a lantern to their feet, they pursued the primary task of ensuring victory. Now that the consummation of their years of labour, if still distant, is yet within sight, and as the need for practical decisions becomes imminent, we may hope to hear more and more frequently from those whose opinions are based upon long experience and expert knowledge.

Amongst the bodies that speak with authority on all subjects associated with the industries of the United Kingdom, none holds a higher position than the F.B.I. It represents all industries and has unequalled means for ascertaining their views and their reactions to any proposals or to any lines of thought that may be worthy of attention. Hence it is in a position to speak with certainty and to reflect the opinion of the industrial leaders of this country. Especial interest therefore attaches to the speech which Sir George Nelson, its President, delivered on October 29th in Manchester, as reported in our last issue. Although the speech was in a sense personal, it may no doubt be taken as representing the views of the Federation. It is *ex cathedra*, though informal. In the matter of post-war controls Sir George takes the moderate course, which is beginning to secure general acceptance. He agrees that rationing and control must be carried on for a time, but on a diminishing scale as the rate at which supplies become available increases. Only thus can inflation be prevented by a rush to purchase a limited volume of commodities. On the other hand, he urges the reduction of taxation as early as possible after the war and appeals for relief to be given "for depreciation on buildings; amortisation of patents and wasting assets, and adequate relief for research." It is, perhaps, not always remembered that all taxes have in the long run to be paid by industry either directly or indirectly. Hence the cost of industrial products to the consumer varies with the rate of taxation. Lowering taxation has the effect of augmenting the purchasing value of the pound sterling and thereby increases trade. Since the object of the Government will be to set the wheels of peaceful industry in rotation as soon as possible, it may be safely anticipated that reduction of taxes will be found amongst the first items on its agenda. Sir George devoted a great part of his speech to private enterprise, and there again he represented the moderate attitude which is now beginning to replace that of those who have advocated State ownership of everything. It is now generally agreed that the nationalisation of certain things, notably public services, may be desirable, but the opposition to the attack upon individualism is increasing in weight. Sir George is in no doubt about the danger of nationalising industry. "Speaking for myself," he said, "I am quite convinced that if industry were to become nationalised we should become a second-class nation and our workpeople would not be able to retain their present standard of living. . . . Nationalisation would mean the gearing of industry to the State machine. Its speed would be that of the slowest unit. Individual effort would not be free, and the individual would become a cog in a gigantic mechanism." He then gave, in words which those who follow these important movements have already studied, a brief but effective summary of the arguments in support of individualism in industry and in opposition to nationalisation of everything.

Sir George Nelson's speech, it will be seen, outlines the policy that may be expected after the war if the demands of industry are allowed to outweigh the untried policies of academic reformers. Some may see in it a return to the *status quo* and object to it on the grounds that it puts forward no proposals for removing the errors of the past. But it must not be overlooked that Sir George was dealing only with industries, that he stressed the duties and responsibilities that must be borne by the directors of industry, and above all that he expressed the opinions of industrialists themselves, who may justly be held to know more about their own affairs and the needs of trade than those who dictate policies from study tables.

Wages by the Hour

ATTENTION may usefully be drawn to the article which Lord Perry, chairman of the Ford Motor Company, Ltd., has been so kind as to contribute to our columns to-day. His subject is not a new one. For many years difference of opinion about the relative merits of payment by the hour and payment by the piece has existed. Lord Perry presents the case for the former concisely and forcefully. He endorses the principles propounded by Mr. Henry Ford, viz., liberal wages for a good day's work, irrespective of the precise output.

From the employers' standpoint, there can be little question that this is the better plan. It avoids a great deal of accountancy and all friction about the adjustment of rates, particularly that very troublesome problem of changing the rate if the method of performing a job is altered. From the workman's standpoint, there is also much to be said in its favour, and there has always been a large section of labour that is opposed to piecework and to bonus schemes. But during the war piecework of one kind and another has become practically the standard method of payment, because it is held that the incentive to a large output outweighs all other considerations. It remains to be seen whether, when factory conditions return to normal, both employers and employees will be ready to reconsider the problem and to look for means of getting rid of the troubles, expense, and irritations of piecework by the adoption of an hourly rate. It will be observed that the Ford plan, as we may call it for convenience, turns upon the establishment of a basic wage. That wage must be adjusted to what Lord Perry calls "human necessities." It is the minimum wage on which a workman can live decently in the conditions existing at the time and place. But no workman who was not worth more than this minimum would be likely to enjoy steady employment. It is assumed that all those engaged will be worth more, and "the quality of work and the capacity of the workman are rewarded according to supplemental payment or rises." Thus, it will be seen, the scheme gives, in fact, all the workpeople the status of salarians. No office workers are

paid by the piece. They are paid according to their merits, to their usefulness in their vocation, and to their years of service. If factory labour is to take on a new dignity under the provisions that are to be made for education and training in the new scheme of things, it may be that opposition to piecework will increase and that payment by the hour will be extended at the wish of the workers themselves.

Two questions will certainly arise in connection with this matter. The first is whether the methods followed in the Ford factories render the adoption of straight day wages relatively easy, whereas the conditions in a great many other factories, or in particular shops of a given factory, make piecework or premium bonus almost imperative. We have little doubt that Lord Perry would reply that the principle is not affected by the conditions, but others may take the opposite view. The other question is the ticklish problem of the basic rate which is, in fact, the essence of the scheme. Lord Perry, it will be observed, desires to take this out of the hands of district employers and unions. His proposal is that Imperial Parliament should "settle what was the basic wage, *i.e.*, the provision of livelihood." We have already the Board of Trade Cost-of-Living Index. Could it be used to establish a basic wage or would provision have to be made to meet other considerations, such as the amenities of life? We foresee no little difficulty in establishing a basic wage, but if it can be established, it would, we agree, provide the foundation for the consideration of a revision of wage systems.

Piecework and Payment by the Hour

By LORD PERRY*

WHEN I started as an employer I had only a few hundred men and was able to watch them all individually. I tried out piecework, bonus systems, and other methods of payment in my limited way, but came to the conclusion that straight wages, *i.e.*, payment by the hour, was the most desirable system.

When an employer goes out to buy labour, he is really purchasing a commodity, and in most businesses it is a very big investment. Good labour therefore should be purchased, and as money is the yardstick for measuring value, obviously good wages or high wages should be a good investment. In my experience, this has proved to be the case. Consequently, in practice I set out by asking myself what must be the minimum or basic wage. Such a wage really has nothing to do with the quality of work, for, inasmuch as all human beings are "fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer," every man, however humble his capacity, *e.g.*, a floor sweeper, has human necessities which should be covered by his basic wage. Once this basic wage has been determined, it becomes the minimum wage. After fixing such a wage, then the quality of work and the capacity of the workman are rewarded according to merit by supplemental payment or rises.

The working of such a practice obviously involves a study of the workman and a determination of what is his value. Many employers have avoided this personal responsibility by making a workman into a sort of sub-contractor, and thereby inferring that he is a potential master man, whereas I am afraid I believe that God made most of humanity to be servants depending entirely upon a cream of leaders for direction.

The time expended in connection with booking up and working out piecework and bonus prices is appalling, and those dealing with labour on the engineering side admit that all the various bonuses, going back to the last war, are very troublesome and waste a lot of time, in spite of ready reckoners. But a return to an inclusive time rate cannot be made without interfering with the established piece and bonus rates which are based on the existing basis time rate.

Piecework involves also other problems, such as inspection and negotiation; hence the accretion of power by trade unions officials, who claim that the workman is not a potential master, and therefore capable of negotiating for himself, and consequently set up a system of interference by outsiders with the management of business.

Under a piecework system there is a very natural incentive for a workman to be slipshod and dodge the inspector. I believe there is frequently collusion between a workman and an inspector, and therefore super inspectors are necessary.

At the time of the original fixing of the piecework rate the employee is frequently as ignorant as the master, and the consequence is that, as the workman becomes efficient, his wages become inflated and there is over production. The master then, sometimes greedily, because he is jealous of the high wages earned by the pieceworker, and sometimes compelled by economic necessity because of over production, finds it necessary to reduce the piecework rate. And there trouble and dissatisfaction, misunderstanding and misrepresentation, begin.

My experience is limited and small, and confined to one class of industry, but I feel certain the high principle involved is a correct one. Just as foremen and other employees engaged in the management are rewarded by increase in straight wages, so I believe the humblest workman should be rewarded.

Taking the example of the man who sweeps the floor, there are good and bad floor sweepers. No one would pay floor sweeping by piecework; if he did, his factory would be full of dirt in the corners and in hidden places, because the man would shirk his duty. The work of a good floor sweeper sticks out, and is at once noticeable, and, as a consequence, the man gets promoted into more responsible work, and hiswages are increased.

My experience over thirty years has consistently proved that high wages are a good investment and straight wages are an economy, as the expenses of inspection and complicated bookkeeping are avoided and replaced by scientific time study and a constant care that square pegs are not forced into round holes.

Inasmuch as the vast majority of our adult population has nothing to sell but its labour, and society in general seems to have accepted the principle of responsibility for the provision of adequate food, housing, sickness attendance, and old age pensions, it would seem that instead of taking so many bites at this cherry of responsibility as are practised at present and formulated in the proposals of the Beveridge Report, it would be most economic and efficient in the national interest if Imperial Parliament were to settle what was the basic wage, *i.e.*, the provision of livelihood.

The basis of trade union demands for minimum wages is regulated by the cost of living, and as a consequence, if the cost of living on a scale approved by the whole population, as expressed by their representatives in Imperial Parliament, were fixed as a basic wage, then the multifarious social obligations would be automatically provided for. Skill and merit obviously would be a supplement superimposed upon such national basic wage and they could be rewarded either as bonus wages, piecework calculations, or, as I think the best way, by increased permanent wages ascertained by an employer after careful time study of the individual merits of each employee in the work in which he is employed.

The chaotic condition of workers' remuneration as fixed by piecework in munitions production at the present time is probably the very best argument which can be used against any such method of rewarding superior labour over and above an established national minimum basic wage.

* Chairman, Ford Motor Company, Ltd.

Obituary

CARL EDWARD JOHANSSON

IN last week's issue we briefly recorded the death, on September 30th, at the age of seventy-nine, of C. E. Johansson, the inventor of the precision gauge system with which his name is universally associated. In announcing his death, we stated that it occurred in the United States. We now learn from the Swedish International Press Bureau that it took place at Eskilstuna, the Swedish hardware town in which the creative period of his life was spent, and where he founded the industrial enterprise bearing his name.

Carl Edward Johansson was of peasant stock, but his mind was always bent toward mechanics. In the early 'eighties he was in the United States, where he put the finishing touches to his training as a mechanic. On his return to Sweden he was employed in the Swedish Government's smallarms factory at Eskilstuna, becoming later master mechanic and head of the tool department, where the making of machine tools and gauges for the factory was carried on. It was in the course of this work that the idea of a universal measuring system entered his mind, as a result of his experience that the measurements of different manufacturers, both in the same country and in different countries, never agreed.

In 1896 Johansson completed his first combination measuring set, but it was not until 1907 that the first gauge block sets of the Johansson system were placed on the market. The precision which he achieved was so great that it seemed inconceivable, and his invention was received with great scepticism even in leading scientific quarters. Gradually, however, all had to give in before the evidence he produced of the exactness of the blocks and the reliability of his measuring method. The method makes possible measurements with an accuracy of a few millionths of an inch.

In 1911 there was founded in Eskilstuna the firm of A/B C. E. Johansson, which began making the precision measuring sets on an industrial scale and which is still manufacturing them for the entire world market, except America, the manufacturing rights

for which were transferred to the U.S.A. In addition to gauge blocks, the company is a large manufacturer of precision tools, including micrometers, limit gauges, and other modern measuring instruments, such as surface indicators, hardness indicators, extensometers, &c. The American automobile industry was one of the first to recognise the importance of the facilities which the system offered for series manufacture, and Henry Ford, in particular, adopted it on an extensive scale. Towards the end of his active career Johansson held for some years an important post with the Ford Motor Company, in Detroit, and only retired from it to come back to spend his declining years in his old home town of Eskilstuna.

Johansson was a member of the Swedish Academy for Engineering Research and Honorary Doctor of the Gustavus Adolphus College at St. Peter and of Wayne University, Detroit. About ten years ago he received the John Ericsson Gold Medal from the Swedish Engineering Society in the United States, and in 1940 he was awarded the Gold Medal of the American Society of Mechanical Engineers.

JOHN JENKIN ASHTON JONES

We regret to have to record the death, on November 1st, of Mr. J. J. A. Jones, of the central research department of the United Steel Companies, Ltd., Sheffield. John Jones was born in May, 1894, and graduated from Aberystwyth in 1915. Shortly afterwards he joined the Royal Welch Fusiliers and saw active service in the Great War. In 1917 his military service was terminated as the result of wounds, and he joined the research department at Woolwich, where he assisted Dr. Greaves, in conjunction with whom he presented four papers before the Iron and Steel Institute, of which he became a member in 1920. He was co-author of one other paper, and in his own name contributed six further papers to the Institute.

In 1930 he joined the United Steel Companies, Ltd., and, with Dr. Swinden, director of research, he took a large part in planning the central research department of that group at Stocksbridge. When the central research department opened, he became the manager, a post he held up to the time of his death.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

CHANGE GEAR CALCULATIONS

Sir,—I have read the article by Dr. H. E. Merritt in The Engineer for October 8th, dealing with the above subject and giving full particulars of the academic solution for converting a decimal fraction into a vulgar fraction. As this operation is apparently more commonly carried out than would seem probable, may I offer the following method ?

The decimal fraction is selected on the "D" scale of a slide rule and the ten of the "C" scale is brought into alignment. Starting from 1 on the "D" scale, the cursor is moved slowly along and the points at which whole numbers on the "D" and "C" scale coincide approximately are noted. Thus we get, taking Dr. Merritt's example of 0·606, the two figures quoted by him, *i.e.*, 20/33 and 23/38, with a further combination of 43/71.

For most practical purposes, any of these fractions would be satisfactory, but where the most accurate ratio is needed I usually check the two or three available fractions with five-figure logarithms, and select the best result in this way.

This may sound rather a long process, but the preliminary selection with a slide rule can usually be carried out in 30 sec., and very often only two results appear which are likely to be useful, so that final selection is quite simple.

H. O. Bradshaw.

Northfield, Birmingham,
November 9th.

THE PROFESSIONAL CONFERENCE ON TOWN PLANNING

Sir,—In present circumstances nothing could have been better timed than the conference of engineers, architects, and surveyors to discuss the appropriate spheres of work in town and country planning for each of these professions, and there does not appear to have been dissent from the conclusions of the speakers. Yet it must be pointed out that the meeting was called for one specific object and not definitely to determine their functions in the whole range of their duties. If, in so intricate a problem as town planning, agreement can be reached on their respective duties, there seems to be no valid reason why the whole range of those duties cannot be allocated. Not only is there much overlapping in these three professions, but there are many institutions where the overlapping is so extensive as to demand amalgamation, or sufficiently extensive to demand allocation of duties.

There was a time when civil engineering practically held the field without competitors, but in process of time there has been such a development of special forms of engineering as to call for the establishment of separate institutions to deal with them. But the logical development of the process has not been realised. Of the parent body it is said: "In fulfilment of its chartered objects the Institution embraces in its activities all branches of civilian engineering, and includes structural, municipal, mechanical, electrical, mining, marine, and other professional engineers and naval architects on its roll as corporate members and students," whereas these objects should have been modified by eliminating from them those for which specialist associations had been formed. The position is decidedly uneconomic. There is an enormous waste of human energy in these duplications of functions. There is a crying need for delimitation of functions. "The worst thing that could happen at the present time," said Mr. Manzoni, "—unfortunately it has been happening—is that members of the different professions should continue to cry aloud their own claims by derogating the claims of others, because this must inevitably shake the confidence of a public which is becoming more interested and more informed, not to mention more clamorous, concerning the post-war world."

Mr. Manzoni showed how in the case of Duddeston the district came to be planned. The reason was purely sociological. The medical officer of health reported on it to the surveyor, who dealt with it from his point of view, and then discussed it with Mr. Manzoni, the city surveyor of Birmingham. He set the Town Planning Department to work. Then the road engineers were instructed and zoning for industrial and residential purposes was considered contemporaneously. Lastly, the lawyers had to be consulted to comply with legal formalities.

In epitome this shows how a great city can provide all the specialists required from its own staff. It shows also the order of operations. It further shows what officials are required for a town planning scheme. But it shows much more. If there were in existence a federation of the professions, the functions of the professions concerned in such operations would be defined for the whole country and bickering would cease. Similarly, if the Government required guidance on a new development of economic life, the Federal Council would be empowered to determine what professions should be employed or taken into consultation in its execution. Suppose, for example, that the Government decided that all hospitals should be taken over by the State, the Council would nominate suitable men and women from all appropriate professions to carry out the scheme and to construct new hospitals as required. The professional men and women would include engineers, architects, surveyors, doctors, lawyers, medical officers of health, sanitary inspectors, nurses, and midwives. The Federal Council would appoint the required number and variety of councillors to form a committee to carry out the plan and so for any other purpose.

In his Presidential Address to the Institution of Mechanical Engineers, Professor F. C. Lea remarked: "It is not possible to divorce the various branches of engineering from each other, nor even electrical engineering from mechanical engineering." Nothing could indicate more clearly the need for co-ordination of all engineering bodies. When that is done, the Council of Co-ordination should take its place along with all other professional bodies, whether multiple or single in character, in the Federal Council of the federated professions.

A. W. Crampton.

November 6th.

Sixty Years Ago

Electric Locomotives

In his recent Presidential Address to the Institution of Mechanical Engineers—see our issue of October 29th—Professor F. C. Lea, describing engineering as it was fifty years ago, asserted that "no electric locomotive had been constructed." Doubtlessly by this time Professor Lea has had his attention called to the erroneous nature of this statement. It would still have been erroneous if he had extended his survey a further ten years back. The first electric railway using an electric locomotive was constructed at Berlin by Siemens and Halske more than sixty years ago. By 1883 a fair number of similar railways were in service. On September 28th of that year the Portrush and Giant's Causeway electric railway was opened, power being obtained from a waterfall on the River Bush by means of two hydraulic turbines driving Siemens dynamos. About the same time Volk's electric railway at Brighton was set to work and another one was in operation at the Crystal Palace. An illustration of a contemporary electric locomotive is to be found in our issue of November 16th, 1883. It was built by Siemens and Halske for use underground in a mine at Zankeroda, Saxony, and consisted of a four-wheeled vehicle with a driver's seat at each end. It carried a motor coupled through gearing to the axles and obtained its power from a conductor fed by a steam-driven dynamo outside the mine. It was a locomotive in the sense that it was an independent vehicle designed to draw a train of trucks attached to it, and was not simply a car or truck with a motor to drive it. The fact that it did not produce its own supply of electricity, but was dependent upon an outside source, would not, even to-day, disqualify it from being called an "electric locomotive."

The Conservation of Coal.—Dr. E. S. Grumell, Melchett Medallist this year, in an address to the Institute of Fuel, urged the conservation of coal resources as a keynote of the future. The real question was how long the available coal could be got at a reasonable cost. The answer was that, in the opinion of a number of people, the best seams would be worked out in from thirty to fifty years, and coal would be extremely costly unless vastly improved methods of mining were devised.

Deposits on Economisers

At a joint meeting of the Institutions of Mechanical and Electrical Engineers on Thursday, November 4th, two papers, "Bonded Deposits on Economiser Heating Surfaces," by J. R. Rylands and J. R. Jenkinson, and "Causes of High Dewpoint Temperatures in Boiler Flue Gases," by W. F. Harlow, were read. Abstracts of those papers are printed on another page of this issue. Below we print an abstract of the discussion.

Mr. M. H. Adams: It is not within my province to discuss chemistry, but I should like to say that in my view the chemistry of these two papers has been so simplified and idealised as to make it rather misleading. Mr. Harlow is almost certainly right in saying that sulphur trioxide or sulphuric acid vapour is created during the passage of the gases through the superheater, but I think that we ought to keep our minds open as to the possibilities of its formation in very much larger quantities in other ways. Again, aluminium salts may act as a bonding material in the economiser, but other substances may play a similar part in other portions of the plant.

The mechanism described by Messrs. Rylands and Jenkinson is very ingenious, but when I first read the paper I found it very difficult to believe that the sulphur dioxide was clever enough to find its way through ¼in. of very solid scale and do its transformation on the tube surface. I shall be glad to know from the authors whether they have any proof that the sulphur dioxide can penetrate through this hard bonded scale.

From practical experience, it would appear as though our troubles had increased with the increase of superheat temperature, but I think we must remember that other things have altered during the period that the superheat has increased in temperature; for instance, there is the feed temperature, which is mentioned in the paper by Messrs. Rylands and Jenkinson, and there is also the higher temperature of the boiler tubes, due to the higher pressure, and, what I think is more important than anything else, there is the fact that we are trying to get more and more from a square foot of heating surface and from a square foot of grate area. It is this question of rating which I think wants very careful investigation. I think that we are expecting rather too much from our station engineers and from our stations. It seems to me that it is impossible to have super-efficiencies, high load factor, high rating, and high availability all at the same time. The efficiency of a base-load station is of less importance than the efficiency of the area in which it operates; and if we were a little less ambitious with regard to our efficiencies and ratings, and placed more emphasis on availability, we should get a better all-round efficiency, I think, in an area, and I believe that our friends, the Central Electricity Board, would sleep more peacefully in their beds.

Mr. L. S. Fosbrooke: In his paper on the causes of high dewpoint temperatures, Mr. Harlow has, I think, conclusively proved that the final steam temperature is the criterion, acting through the thermal gradient of the tube wall. The catalytic agents vary enormously in their behaviour, as is indicated in one of his diagrams, where over the appropriate temperature range one rises sky-high at the same rate as the other decreases. That may account in some measure for the anomalies and wide differences in boiler practice up and down the country. It is the job of the engineer to surmount troubles and not complacently to disregard the very great advantages of high superheat temperature, so let us try to construct a little budget for the future. I cannot agree that the author's suggestion of injecting pulverised fuel ash or milk of lime is practicable. When one visualises the immense tube areas, the dense nests of modern superheater tubes, it is not at all reasonable to expect that 100 per cent. of that area will be immunised, or that the process will stay put when we have to subject those areas twice every eight hours to extensive steam scavenging. Let us therefore consider designing round the problem. First of all, I suggest that all new installations should be pulverised fuel fired where the geographical and other factors are favourable. That system of combustion enjoys relative immunity from both high and low-temperature deposits. My second suggestion is that since 800 deg. Fah. is the criterion of tube-wall temperature, we should design the primary superheater only as a convection unit, further superheating to be done in a radiant unit disposed in the water walls at the top of the combustion chamber. By that arrangement the combustion gases would not intimately scrub the catalytic area.

The other suggestion put forward which merits serious consideration is that the primary superheater only should be integral with the boiler unit, and that further superheating should be done through a unit independently fired, either by pulverised fuel or boiler fuel. This arrangement could be linked up even with a reheat installation, but I am afraid that on a large-scale lay-out this would lead to great complications.

Mr. F. Shakeshaft: Attention has been directed to investigating the phenomena which occur in the fuel bed of stokers, as it was felt that during the burning-out process of the rear of the stoker chemical reactions take place which might be largely responsible for some of these troubles. Recent experiments which have been carried out after making modifications to the air zoning of chambers and stokers give promising results, as they have enabled boilers to remain on the line for from 3000 to 4000 hours, instead of 600 hours.

Mr. B. M. Thornton: In my company, we have been operating stoker-fired high-pressure boilers with moderately high superheats for some ten years. All these boilers are equipped with air heaters, and we have often wondered why we have been so comparatively free from serious fouling and corrosion troubles. Some years ago we measured the temperature of our superheater tubes during starting and normal running by means of thermo-couples peened into the tubes, and we established that during normal running the tube temperatures were from 50 deg. to 80 deg. Fah. higher than that of the superheated steam. These figures confirm those given by Mr. Harlow. Our final steam temperatures varied from 780 deg. to 820 deg. Fah., and normally never exceeded 820 deg. Fah. By actual test, we established that our normal highest average tube temperature was about 850 deg. Fah. Mr. Harlow's curves now offer a possible explanation of our comparative freedom from trouble. It is evident that we have been working on what might be called the safe part of the curve, and it would appear that our experiences are some confirmation of his thesis.

Mr. F. Fraser Ross: There is, unfortunately for boiler designers, a good deal of technical evidence in favour of Mr. Harlow's theory, and as far as our knowledge goes the theory is scientifically sound. We are examining the technical evidence, and, if the theory is proved, the "back-room boys" will have to find out how to treat superheater surfaces in a practical way to prevent the catalysis. Although personally I am not prepared to subscribe to the theory at the present stage, it is impossible for me to point to one single solid fact against it, unless the observation that superheater surfaces are, in general, coated with deposit and their metal is not in any case exposed to the flue gases is considered as such. What is surprising therefore is that there is so far no support for it from scientific measurements on boilers. It is obvious that, if this theory is correct, there should be a marked difference in the amount of sulphuric acid content of the flue gases before and after the superheater in every stoker-fired boiler. This has never been confirmed, either by analyses of flue gases for sulphur trioxide or by measurement of dewpoints. There are difficulties in both these measurements which have to be experienced to be believed, and until these have been overcome the wisest course seems to be to allow that the measurements so far made may be explained by circumstances not yet understood. Until we have evidence which constitutes proof, however, it would also be wise to regard this theory as no more than a theory, and not to jump to the otherwise inevitable and unpleasant conclusion that superheat temperatures of above 850 deg. Fah. are impracticable unless a satisfactory means of coating the tube surfaces can be found, or unless boilers can be radically redesigned, as Mr. Fosbrooke has suggested.

Mr. R. Ll. Rees: Messrs. Rylands and Jenkinson have shown that a characteristic deposit may be built up by their method, but the experiment certainly does not show that such a deposit cannot be built up in any other way. It is probable that the characteristic structure of these experimental deposits is the result of aerodynamic effects, possibly assisted by thermal precipitation, and that aluminium sulphate or any other bonding agent merely gives the deposit its mechanical strength. If that is so, this particular criterion cannot be used as a means of judging the validity of rival theories, because aerodynamics and thermal precipitation must play some part in any theory that can be formulated to account for the formation of these deposits.

Every deposit that I have seen, including even typical "bird-nesting," had as its foundation next to the heating surface a thin layer that was distinguishable from the rest of the deposit; from which observation it is surely permissible to draw the inference that the surface of a new tube must undergo some definite change before deposits, however they may be formed, can build up on it. The authors have given a possible explanation of such a change which is not, as I see it, an essential part of the aluminium sulphate theory, and can readily be adapted to fit other theories.

Enough has been said to make it plain that the authors have given a most ingenious and valuable theory of the formation of economiser deposits, but that they have failed in their attempt to prove that no other theory is valid. It is easy to believe that these deposits can form in more than one way; indeed, the complexity of the problem suggests that several different mechanisms may operate simultaneously, so that there is still a wide field of ideas open for investigation.

The paper by Mr. Harlow formulates a

theory of the formation of sulphuric acid vapour in flue gases against which it seems impossible to produce any valid scientific arguments. There is every reason to suppose that some sulphur trioxide or sulphuric acid vapour must be formed as the gases pass through the superheater, but one cannot agree that this is the only possible method of formation, and, in view of the serious practical implications of Mr. Harlow's theory, it is especially desirable to be clear about this matter.

The statement on the first page of the paper, that "it would seem that it is impossible for an excessive amount of sulphur trioxide to be produced in the combustion process," is based upon the results of experiments made by Bodenstein and others, who calculated the equilibrium constants of the SO_2-SO_3-O_2 reaction from experiments made under ideal conditions in the laboratory. The actual conditions in a boiler furnace are very different, however. Not only is it doubtful whether equilibrium is reached, or even approached, but the reactions in the boiler furnace are taking place at great dilution, in the presence of several other gases, including carbon monoxide, and in the presence of quantities of finely divided solids, and in the immediate neighbourhood of an extensive release of energy. It would be surprising if the Bodenstein curve was found to hold under conditions such as these. We do not know yet how much it differs from actuality, nor even the direction in which it differs, but there is certainly a possibility that the gases leaving the combustion chamber may contain harmful quantities of sulphur trioxide. Fortunately, the theory given in the paper is amenable to experimental test by direct observations on operating boilers and by the collection of statistics. There are serious difficulties attached to both these methods of testing the theory, but there is no reason to suppose that they cannot be overcome, and one may look forward to a definite verdict.

Dr. A. A. Taylor: The conclusions which are reached in Mr. Harlow's paper are not, I think, quite justified, because of the very great differences which occur in the experimental procedure as compared with what happens in a superheater. For example, in his experiments he used a much cooler gas, and one which probably contained a much higher proportion of air. The gases entering the superheater would probably contain very little oxygen. There may also be a great difference between the flue solids in a flue gas entering a superheater and those used in the experiments. In a superheater, hot gas passes over a cool surface, whereas in these tests a cool gas was passed over heated surfaces.

Again, in any catalytic process one of the most important facts is the time of contact between reactant and catalytic surface. Iron oxide is a slow converter of sulphur dioxide to sulphur trioxide, and I do not think that Mr. Harlow is quite justified in dismissing this point as he does. It is quite possible that in a superheater the gas velocity is such that there is insufficient time or insufficient contact for these catalytic effects to take place.

With regard to the catalysts, I would suggest that the iron oxide on the tubes, which was found in the experiments to be the most effective catalyst, would not be operative, because the tubes in normal boiler practice would be coated after quite short running periods with a layer of deposit. This was suggested by Mr. Rees, but not elaborated by him. In a superheater it would therefore be the deposit which would be the controlling factor. The effect of the superheater deposit is very small, and up to temperatures of about 1100 deg. Fah. there is really nothing to choose between the superheater scales and the pulverised fuel dusts; at the same temperatures they have almost exactly the same catalytic effect. If low dewpoints are obtained with pulverised fuel plants because the tubes are coated with a layer of pulverised fuel dust, then on a stoker-fired boiler a low dewpoint should also be recorded, because of the equally small catalytic effect of the superheater scale.

Mr. G. Nonhebel: I should like to support the suggestion which has already been made that a radiant superheater is the right thing for the final stage of superheating if Mr. Harlow's theory is correct. I have had experience of radiant superheaters with a powdered fuel boiler of the Stirling type, where a brick baffle directly opposite the turbulent burners was replaced by a radiant superheater, and the superheater has stood up very well to those conditions. As it is a powdered fuel boiler we have not, of course, suffered from air heater corrosion.

Mr. D. Northall-Laurie: I spent most of 1935 on a comprehensive research at two large power stations on the general question of the production of sulphur in the flue gases, and more especially the elimination, if possible, of the sticky deposits in the air heaters and economisers and the elimination of corrosion. The sticky dust, which we all know about, was acid, and I shall not refer to that now. The problem seemed to resolve itself into the addition of an alkali, and also it was necessary to control the moisture content of the flue gases. No reduction of this acidity was possible by burning coal containing lime; the quantity required was so excessive as to make it quite impossible. I then tried the addition of lime dust to the flue gases, and an apparatus was set up above the Stirling boiler so that measured quantities of lime dust could be blown in immediately over the economisers. We started the experiment by adding 3 per cent. of lime dust, calculated on the quantity of coal burnt, and it was found that there was no deposit at all formed in the air heaters and no corrosion. This quantity was gradually reduced, and eventually I found that 0·2 per cent. of lime would prevent any deposit of sticky material, and also the dust was still slightly alkaline. The quantity of sulphur in the coal was 2 per cent. It was thus found that by the addition of an amount of lime equal to one-tenth of the sulphur content of the coal, with controlled humidity (about 1·5 grammes per cubic foot at N.P.T.), all deposits became mobile and did not stick, and there was also no corrosion. Runs went up to nine weeks, and it appeared to be a solution of the problem.

Mr. Rylands and Mr. Harlow said that they would reply in writing to various points raised in the discussion.

South African Engineering Notes

(By our South African Correspondent)

CAPE TOWN, August 30th.

The Vanderbijl Works Plate Mill

THE equipment of the Vanderbijl works is proceeding somewhat faster recently, much plant having arrived from overseas. The plate mill has now been installed and will probably start rolling armour plates before the end of this month. The new works are controlled by the South African Iron and Steel Industrial Corporation, and are situated at Vereeniging, in the Transvaal. The plate mill, which is designed to roll sheared plates, $\frac{1}{4}$in. to 1$\frac{1}{4}$in., of 96in. maximum width, from reheated steel slabs, 10in. thick by 30in. to 40in. wide, is four-high reversing, with rolls each 38in. diameter and weighing 30 tons, together with back-up rolls, 52in. diameter and of 47 tons. These rolls are accommodated in two housings each of cast steel in one piece, 30ft. high by 13ft. wide by 4ft. 7in. deep, and weighing 110 tons.

New Railway Works at Pretoria

A new railway marshalling yard and locomotive sheds constructed at Capital Park, Pretoria, were officially opened by the Minister of the South African Railways and Harbours on June 7th. The works are part of the big railway development scheme in the Pretoria area, which also includes a new goods yard recently completed and a new line to Koedoespoort. The work on the marshalling yard and locomotive shed was started in 1939 and was therefore mainly completed in wartime. The locomotive shed is the most modern and among the largest in South Africa, capable of holding 160 locomotives. The water softening plant attached to it is the only one of its kind in South Africa, and in its construction much South African material was used.

The works at Capital Park were the second step in railway development in Pretoria. The first step was the recent opening of the goods yard at Potgieter Street, which cost £258,000 to complete. The second step was the marshalling yard and locomotive depôt. The fact that the amount of goods handled in Pretoria has doubled from 1931 to 1941 gives an idea of the development of goods traffic that has taken place. The present works—the marshalling yard and locomotive depôt—cost £750,000 to complete and of this, £80,000 has been contributed by the Pretoria City Council. The Minister of Railways stated, at the opening ceremony, that much more had to be done in Pretoria. New railway buildings had to be constructed on a site near the City Hall. The line to Capital was to be electrified and one of the first tasks would be the lowering of the railway line running through the eastern suburbs. The new marshalling yard will materially reduce the night traffic over the line through the eastern suburbs, and only twenty-one trains will now be running throughout the day over this line, instead of fifty-one, the others being diverted to the new line.

South African Ships for the Union

The possibility of developing a South African shipbuilding industry to provide for the construction of deep-sea vessels is being debated in shipping circles as the result of the suggestion made by Mr. F. C. Sturrock, Minister of Railways and Harbours, in a speech on the Rand, that the ships for South Africa's new Merchant Marine, which the Government hopes to see established after the war, might be built in South Africa. The suggestion that South Africa should build ocean-going vessels has frequently been raised in the past and the comparative merits of Table Bay and Durban as the most suitable for such an industry have often been argued. Each has advantages. It is since the outbreak of war, however, that the question of South Africa carrying her own trade (or at any rate her trade in African waters) in her own ships has been given really serious consideration. Nearly two years ago the Government appointed a commission to inquire into the possibilities and the advisability of establishing a South African Merchant Marine, particularly for trading with the East and West Coast territories. The commission has not published its report, but considerable evidence was submitted in favour of a South African Merchant Marine, and the real question, apparently, is whether it should be State or private owned.

South Africa already has the nucleus of a Merchant Marine. She owns approximately 200 registered vessels, apart from fishing boats, totalling 50,000 tons gross. Only eleven of these are employed in general trading, however, the others being fishing, whaling, and harbour craft; and only two of the eleven are ocean-going ships, both owned and operated by the Union Government. Three others, two whaling factories and one Union Government ship, have

been announced as lost since the war began. These figures do not take into account prize ships requisitioned and chartered vessels, operating for South African account for the period of the war. The Union has fewer than a dozen coasters of her own and only one of them is large enough to trade beyond the borders of the Union. It is estimated that before the war 150,000 tons of Union cargo was being shipped annually from one Union port to another in non-South African bottoms.

The industrialisation of the country as a result of the war should greatly improve the Union's position in competing with Europe and the Americas for the trade of other African territories after the war. It will require many more ships to carry that trade. The promised development of the South African fishing industry and the enlargement of the country's harbours will require more fishing vessels and harbour craft.

In normal times South Africa purchased an average of seven vessels a year from overseas shipyards, ranging from 100-ton trawlers to floating docks. In five years before the war she spent approximately £1,500,000 on purchasing thirty-five craft, including two dredgers, five coasters, nine tugs, fourteen trawlers, four whalers, and a 4000-ton floating dock.

Big Post-War Planning Schemes

Recently it was announced that Cape Town had post-war planning schemes that would require at least £30,000,000 to carry through, and these plans were entirely those of the municipality and did not include the Government's programmes, which cover the requirements of that great spending department, the Railways and Harbours. Now, the cities of Johannesburg and Durban have given rough estimates which, though not complete, make it clear that their expenditure will certainly largely exceed that contemplated by Cape Town.

Several other cities and towns are busily engaged in planning for the future, but so far no estimates of cost have been made public. The Government's plans for the future are still under consideration, but the post-war building schemes for its various departments are estimated to cost more than £13,000,000.

Increasing Use of Electricity

After three years of war, despite black-outs and the scarcity of electrical equipment, the Electricity Supply Commission is still increasing its output and sales of electricity in the Union of South Africa. The report of the Commission states that nearly 4500 million units of electricity were generated during 1942. This was more than 100 million units above the 1941 output.

Producer Gas Charcoal

The existing scarcity of liquid fuels has given a great impetus to the use of charcoal as a fuel for internal combustion engines. Portable gas producers have already been fitted to many cars and lorries belonging to the public and the Union Government, and considerable money has been spent by various bodies on research projects dealing with the production of charcoal and the designing of gas producer units. The most important work in this direction has been undertaken jointly by the Forest Products Institute and the Fuel Research Institute, both of Pretoria. The specifications of a charcoal suitable for use in gas producers are very strict. The following maximum contents are prescribed :—Volatile matter, 14 per cent.; tar, 0·05 per cent.; ash, 3 per cent. ; and moisture, 8 per cent. It must be free of impurities, hard, and as free of dust as possible, and its individual particles should be confined within a size range of ¼in. to 1¼in. Realisation of those requirements could not be complied with under pre-war methods of manufacture. With experience gained from experiments it has been possible to develop and perfect a new method of production. A brick kiln capable of producing charcoal conforming to all the new requirements has been designed. It is simple and inexpensive to build, can be attended by natives, and is practically foolproof, assuring uniformity of the product manufactured. The efficiency of these kilns has led to a revision of many old conceptions. In the past it was always assumed that to obtain the best charcoal it was necessary to carbonise wood very slowly. In these new kilns it is possible to turn 5 tons of wood into the best charcoal in from eighteen to twenty-five hours, the charcoal in turn having cooled down sufficiently for removal from the kiln in about as many hours as the burning took. Furthermore, it was formerly thought that a certain amount of the timber in a charge ought to be burnt to ash so as to supply the necessary heat for the carbonisation of the remainder. In the modern type of kiln this is neither necessary nor desirable. The charge is completely carbonised without any of the wood being reduced to ash and remains in the kiln just as it was packed. Steel kilns as used extensively in Europe have been tried. Their main advantage lies in their portability, making it possible to bring the plant to the timber, thus lowering transportation costs and making it feasible to utilise small lots of timber which do not justify the erection of permanent kilns. As a result of these trials a steel kiln has been designed at the Forest Products Institute incorporating standard design modified to simplify operations. The comparatively high capital outlay of from £40 to £60, the existing scarcity of sheet metal, and the greater skill demanded in its operation have reacted in favour of brick kilns, which cost only £8 to £25, according to circumstances.

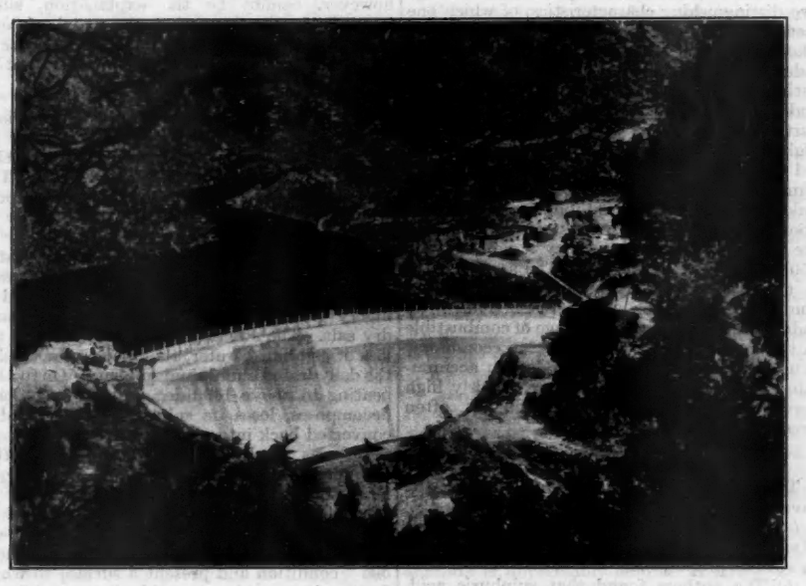
Brazil Makes Bid for South African Markets

Brazil is making full use of the opportunity afforded by South Africa's need of raw materials and manufactured goods, to expand her exports to the Union. With a merchant fleet—which, although small, is capable of fulfilling immediate needs—running from Rio and Santos to Cape Town and not subject to cargo priorities or shipping pools, Brazil is actually in a better position to supply many South African needs than the United States or Britain itself, and in a number of respects the production of South Africa and Brazil are virtually complementary.

The Brazilian Government, in asking its exporters to increase their business with the Union, points out that South Africa has lost none of its purchasing power and is still one of the greatest consuming markets in the world, importing over £100 millions worth of goods annually and maintaining a standard of living as high as that of the United States and second only to New Zealand. Brazil can supply rice, corned beef, boiled beef, and *pâté de foie gras*, hides and skins, manufactured goods from these items (especially children's shoes), timber, women's stockings, crockery, glassware, men's hats, medical products, vegetable oils, and cotton. Brazil would, of course, be glad of Union steel, coal, and copper. In trade circles in Brazil it is understood that definite plans are being worked out to ensure a constant large flow of all those products from Brazil to South Africa. If the quality is improved materially no doubt trade with South Africa will be increased—for the duration of the war.

An Argentine Dam

Recently there was completed in Argentina the dam illustrated in the accompanying engraving. It is 17·50 m. high and 81 m. long, and will provide for the storage of 300,000 cubic metres of water. It forms an important part of works completed a few months ago for the improvement of the water supply of La Cumbre, Cruz Chica, and Cruz Grande, in Cordova Province, and is situated on the San Jeronimo River. Of the three localities mentioned, only La Cumbre had a water supply service before the new works were undertaken, and even that supply was of an inadequate and restricted nature. Increasing demands led to the design and execution of new works by the National Board of Works, at an estimated cost of 757,000 pesos. Owing to the fact that the three towns concerned are situated in a mountainous area and at differing levels, it was found preferable to construct two independent water supply systems, one for La Cumbre and the other for Cruz Grande and Cruz Chica. Works at four catchment areas from which La Cumbre drew its previous supply were enlarged ; the San Jeronimo dam was constructed ; and a new purification plant was installed with a capacity of 1500 cubic metres per day, including a chlorinating plant. For Cruz Grande and Cruz Chica a complete distribution system has been laid ; there is a purification plant, with a daily capacity of 2000 cubic metres ; and storage basins, &c. Water is drawn from the confluence of two streams, Los Laureles and Las Guachas respectively, and from the River Cruz Chica. The limited supplies from these sources are to be augmented by the construction of dams which will ultimately provide a storage capacity of 228,000 cubic metres. Work upon the erection of the dams has already been started.



SAN JERONIMO DAM, ARGENTINA

Train Lighting.—During the summer months the Great Western Railway has improved the lighting in 26,000 train compartments. To improve its train lighting during the black-out, the Southern Railway has fitted 25,000 shades and 18,000 electric lamps, necessitating alterations to the wiring and fittings of over 4000 carriages.

Deposits on Economisers

We reprint below abstracts from two papers read on Thursday, November 4th, at a joint meeting of the Institutions of Mechanical and Electrical Engineers in London.

BONDED DEPOSITS ON ECONOMISER HEATING SURFACES

By J. R. Rylands, M.Sc., A.M.I. Mech. E., A.M.I.E.E.,* and J. R. Jenkinson, B.Met.*

The Present Investigation

The actual processes involved in the formation of hard bonded scale have not yet been explained in a satisfying manner. The authors therefore turned to a renewed examination of the very large number of bonded-deposit samples they had collected, and began by ascertaining what, if any, characteristics were common to all.

In what has gone before, a distinction has been implied between "industrial" and "power station" conditions, and it may be as well to inquire at this point in what important respect these conditions differ, since, as has already been said, bonded deposits on economisers appear to form exclusively under what have been termed "power station" conditions. From the economiser standpoint there emerge two distinguishing characteristics, of which one seems to be more important than the other. The first is the water temperature range. In industry this range in economisers lies almost entirely between the temperatures of 100 deg. and 350 deg. Fah. In power stations, more particularly in recent years, the range is much higher. A power station economiser is seldom fed with water below 250 deg. Fah.; inlet feed temperatures in excess of 400 deg. Fah. are not unknown. The outlet feed temperature is often above 450 deg. Fah. Power stations, therefore, are usually concerned with a range between 250 deg. and 450 deg. Fah. The second point is that combustion is perhaps a little more complete in a power station plant than in an industrial plant. The percentage of combustible in the deposit from a power station economiser is usually negligible. Where a deposit accumulates in an industrial economiser, a fairly high percentage of combustible matter is often present in the deposit.

Deposit Examination

Two facts emerged at an early stage in the investigation :—

(*a*) Coal ash consists mainly of compounds of silica, alumina, iron oxide, lime, and magnesia in various proportions.

(*b*) The authors found that sulphuric acid, and alumina in some form or other, were constituents common to all deposits. They found also that aluminium sulphate is a constituent common to all hard bonded deposits formed on economisers in the "power station" range, *i.e.*, containing feed water between 250 deg. and 450 deg. Fah. Hard bonded deposits from economiser tubes have been analysed, and also the loose dust deposits from nearby ledges. The results given in the table are typical.

Analyses of Deposits

	Station X.		Station Y.	
	Hard deposit.	Loose dust.	Hard deposit.	Loose dust.
Moisture	2·10	0·09	2·35	1·22
Ash	82·80	57·50	68·60	78·90
Insoluble in water ...	82·18	98·00	58·54	82·89
Soluble in water ...	17·82	2·00	41·46	17·11
Total S as H_2SO_4 ...	8·42	0·84	38·98	13·82
Soluble Portion				
Ferric sulphate	0·28	Nil	35·0	5·65
Aluminium sulphate	8·36	Nil	12·00	0·0
Calcium sulphate ...	1·70	0·73	2·99	4·74
Sulphuric acid	5·88	Nil	21·60	5·44

Note.—Aluminium sulphate was hydrated in Station X analyses and dehydrated in Station Y analyses.

Insoluble Portion				
Iron oxide	0·64	0·04	15·26	10·74
Aluminium oxide ...	37·97	17·88	13·45	30·36
Silica	16·40	17·44	12·95	28·90
Calcium sulphate ...	Nil	0·44	Nil	5·76
Calcium oxide	Nil	2·12	Nil	Nil

Water Temperatures

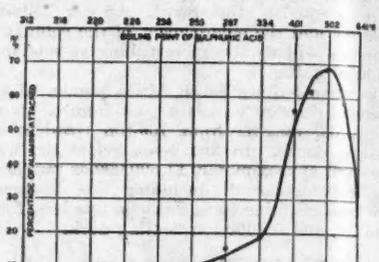
Station X: Inlet 275 deg. Fah.; outlet 356 deg. Fah.

Station Y: Inlet 320 deg. Fah.; outlet 392 deg. Fah.

The dust on and near economiser surfaces is known to contain alumina in some form of chemical combination, the reactions of alumina with sulphuric acid of various concentrations and at various temperatures were examined. As the authors suspected that the rate of attack was associated with the strength of the acid, solubility tests were carried out on pure alumina of specific gravity 3·47. The results are shown in Fig. 1.

In each test 1 gramme of alumina was attacked by 100 cc. of boiling sulphuric acid, the controlled variable being the acid concentration. The amount of unattacked alumina was estimated after each test of twenty minutes' duration.

It will be seen that at lower concentrations the alumina is only slightly attacked. After


BOILING POINT OF SULPHURIC ACID
PERCENTAGE OF ALUMINA ATTACKED
PERCENTAGE BY WEIGHT OF SULPHURIC ACID IN WATER
"THE ENGINEER"

Specific gravity of alumina = 3·47
Volume of acid = 100 cm.³
Weight of alumina = 1 gramme.
Time of each reaction = 20 minutes.

Fig. 1—*Attack of Boiling Sulphuric Acid on Alumina*

70 per cent. concentration an acceleration takes place, rising to a maximum at 90 per cent. Thereafter follows a sharp diminution in the rate of attack with pure acid of 1·84 specific gravity.

These tests were not, however, confined to the action of sulphuric acid on pure alumina. It was realised that alumina does not exist in the pure state in coal ash. Similar tests were carried out on flue dust of various kinds. All the results demonstrated that the curve for pure alumina was typical, whether the alumina was pure or in certain combined states.

From all these considerations and experiments the authors conclude :—

(*a*) That the solubility of the aluminium compounds contained in flue dust depends on the temperature to which the substances have been heated before they come into contact with sulphuric acid.

(*b*) That the rate of attack increases as the temperature and strength of the acid increase, up to a concentration of 90 per cent.

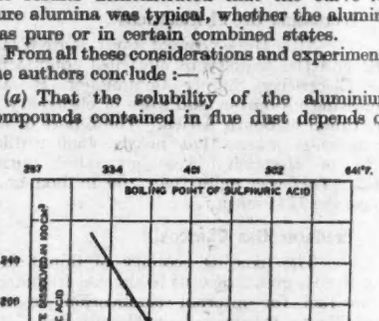

BOILING POINT OF SULPHURIC ACID
GRAMMES OF ALUMINIUM SULPHATE DISSOLVED IN 100CM³ OF SULPHURIC ACID
PERCENTAGE BY WEIGHT OF SULPHURIC ACID IN WATER
"THE ENGINEER"

Fig. 2—*Solubility Curves of Pure $Al_2(SO_4)_3 . 18 H_2O$ in Boiling Sulphuric Acid of Various Concentrations*

Solubility of Alumina

Since the dust on and near economiser surfaces is known to contain alumina in some form

The Bond

The next step was to consider the various analyses to discover the cementing agent or bond. The constituent which occurs in quantity in all hard deposits is aluminium sulphate. The characteristic of this substance, in the pure state, was therefore examined. A number of interesting features were observed.

When aluminium sulphate is quickly heated to above 420 deg. Fah. it swells up and passes through a stage which can best be described as highly glutinous. It finally becomes a hard, dry salt. The swelling stage occurs during the loss of combined water, the final product being the dehydrated aluminium sulphate. On further heating to above 1400 deg. Fah., the sulphate decomposes, loses its sulphur trioxide, and is converted back into aluminium oxide.

It was realised that if the formation of hydrated aluminium sulphate — $Al_2(SO_4)_3 . 18 H_2O$—took place in a deposit, and if at some subsequent stage it was thrown out of solution in an atmosphere above 420 deg. Fah., it would immediately pass through the "glutinous" condition and present a surface to which further dust could and would adhere, and finally result in a bonded deposit having the familiar characteristics.

These considerations appeared to indicate a promising line of research, more especially as the reactions involved in the formation of aluminium sulphate in the deposits seem to have received little attention.

Johnstone says : "A large part of the sulphur present in the deposits exists as iron and aluminium sulphate. These are undoubtedly formed from the fly ash itself, and are not the result of any action of sulphuric acid on the ash."

The authors find this statement unsatisfactory. Most authorities agree that in the coal ash the aluminium occurs as aluminium silicate. To form the sulphate, the necessary sulphate radicle must be added by the direct action of either sulphur trioxide or sulphuric acid. But the gases contain very little trioxide, and any such reaction occurring during the passage of the dust from the combustion chamber to the economiser must be very limited.

If, however, the minute particles of alumina were to lodge on the tubes bearing an external film of hot sulphuric acid, the conditions would be propitious for the formation of aluminium sulphate. Time and opportunity would be favourable.

Solubility of Aluminium Sulphate

The next matter calling for investigation was the solubility of aluminium sulphate in sulphuric acid, and appropriate tests were made. Fig. 2 shows the results. As the acid increases in

* E. Green and Son, Ltd.

strength the solubility decreases, or, in other words, the amount of aluminium sulphate which can be held in solution becomes less. Thus, if the acid concentration of a saturated solution of aluminium sulphate in sulphuric acid is increased, some aluminium sulphate will be thrown out. It will be shown later how this consideration of the solubility of alumina compounds not only contributes to the explanation of the behaviour of dust from pulverised fuel firing, but may prove of value in devising methods for the prevention of deposits from stoker-fired plants.

Occurrence of Sulphuric Acid on Economiser Surfaces

It is known that when an economiser first goes into commission it may have a long period of immunity from bonded deposit accumulation. This is ascribed to the absence of any sulphuric acid films on the tubes; such a film must exist before the growth of deposits can commence. The only direct source of sulphuric acid is the sulphur trioxide in the gases. The necessary moisture can be deposited only when the tubes are at a temperature below the dewpoint of the gases. It is appreciated that the latter conditions should apply but rarely in the case of power station economisers. In general, power station economisers work with water temperatures well above the moisture dewpoints of the gases.

The authors imagine, therefore, that the process is on the following lines:—During the period of immunity the economiser tubes are gradually directly attacked by the gases containing small amounts of sulphur trioxide and water vapour. Ferrous sulphate is formed, and this oxidises to ferric sulphate. During this comparatively long period, however, the surface of these tubes appears to be perfectly clean, since the ferric sulphate is present only in minute quantities. Ferric sulphate, however, is not only deliquescent, but is a powerful catalytic agent capable of converting sulphur dioxide into sulphur trioxide. This fact was known and recorded many years ago. Thus once a small deposit of ferric sulphate has been formed, the local "manufacture" of more sulphuric acid from the relatively plentiful supply of sulphur dioxide and moisture can proceed at an accelerated rate. There is therefore, after a long period of what has been termed "immunity," a thin film of sulphuric acid on the economiser tubes. This film collects a minute covering of flue dust or fly ash. If the acid concentration is sufficiently high, the dust may be attacked, aluminium sulphate formed, and the particles may be cemented together sufficiently to prevent their being dislodged by soot-blower action.

The question here is clearly one of requisite acid concentration. The strength of the sulphuric acid appears to be directly related to the temperature of the metal of the tubes. It is known that sulphuric acid is formed by the catalytic process already mentioned, the constituents available being the sulphur dioxide and the water vapour in the gases. It is known that the boiling point of sulphuric acid rises with the concentration, and that to each concentration there is a definite temperature at which the acid on the tube is in equilibrium with the sulphuric acid vapour. It should be noted that even an acid of 80 per cent. concentration (by weight) has quite a low vapour pressure, and this is depressed still further in the presence on the tube of acid-soluble compounds.

At any given temperature, therefore, there must be a definite acid concentration on the tubes. Were the acid at a given temperature more dilute, water vapour would be evolved because the temperature would be higher than that corresponding to the boiling point of the dilute acid. Conversely, a stronger acid would pick up moisture from the gases until equilibrium was reached.

Thus at any given point in the economiser where acid "manufacture" is taking place, the strength of the acid will depend only on the temperature conditions prevailing on the metal surface or in the deposit. The specific quantity of acid at any particular place will depend on the rate at which the "manufacturing" reactions are taking place, and on the character of the gaseous constituents in contact with the actual metal. It should here be noted that a deposit does not prevent the gases from making contact with the tube metal; examination shows that even bonded deposits are porous to gases.

Where a metallic surface is not kept at a temperature below that of the local gas stream, it ultimately attains to and remains at that temperature. No sulphuric acid can form on a surface much above 640 deg. Fah., the approximate boiling point of pure sulphuric acid. Any dust collecting on such surfaces remains as dust, and is practically unchanged throughout the run of the plant. Thus, in the metal parts adjacent to the economiser tubes the prerequisite condition for bonded-scale formation—the initial sulphuric acid film—is necessarily absent. Such surfaces may collect dust, but the deposit remains dust and does not bond.

Power Station Conditions

It is now possible to offer an explanation of the fact that the hard bonded deposits appear to form almost exclusively under power station conditions. It has been shown that the local strength of the sulphuric acid present on an economiser tube surface—or in the deposit—depends on the local temperature. The higher the temperature, the stronger the acid.

It has also been shown that only fairly concentrated acids will attack the alumina compounds carried by the gases, sufficiently to produce the quantity of aluminium sulphate needed to form a bonded deposit (Fig. 1).

It follows, therefore, that the hard deposits will form only under those conditions where the economiser tube temperatures are high enough to ensure the formation of acids of the requisite strength—that is, in the temperature range between 250 deg. and 450 deg. Fah. This is what has been termed the "power station range," and is the characteristic which chiefly distinguishes "power station" from "industrial" conditions.

Stalagmitic Deposit Formations

The development of the theory has now arrived at the stage where it is possible not only to explain the stalagmitic scale formation, but to reproduce in the laboratory the typical characteristic formation.

Observation shows that when a deposit is very thin it is fairly smooth and has a uniform thickness. The underside is in contact with the tube metal, and is at the same temperature as the tube. It is in this region that most of the sulphuric acid "manufacture" takes place, the strength being governed, as already explained, by the local temperature. Examination of the thin deposit next to the tube metal reveals, as might well be expected, the presence of ferric sulphate and of free sulphuric acid.

According to the authors' theory, the sulphuric acid is sufficiently strong to attack some of the alumina compounds in the fly ash which has adhered to form the initial thin, smooth layer. As the acid continues to form, it seeps upwards through the scale. The temperature obtaining on the gas side of the scale is naturally higher than that on the tube side; scale, though porous to acid and to gases, is not a good conductor of heat.

The acid, saturated with aluminium sulphate, becomes supersaturated at the deposit surface, and the excess sulphate is thrown out at the hottest part of the deposit, since stronger acid cannot hold as much sulphate as can the weaker acid.

A small amount of hydrated aluminium sulphate thrown out of solution on the deposit surface is immediately subjected to the high gas temperature. It swells up, passes through the glutinous stage, traps a few particles of fly ash, and hardens off. The particles caught form, as it were, peaks facing the gas stream. The deposit surface becomes covered with small lumps, marking the spots where the sulphate was expelled. These lumps or peaks now become the hottest parts of the deposit. It is at these points, peaks, or ridges that further sulphate is thrown out, and it is at these places that further growth occurs.

As growth advances, sulphuric acid can be formed in greater quantity, since the total amount of ferric sulphate has increased. The surface temperature increases, and the process tends to accelerate. The higher the temperature of the acid, the greater becomes its degree of concentration. The stronger the acid, the less aluminium sulphate it can hold in solution, and the more it must throw out at the deposit surface. The process is thus one of accelerating rapidity. The thicker the scale, the more quickly further scale will form and the rougher will be its surface.

It is also now clear why the deposited scale is stalagmitic in form. The particles of fly ash come from a more or less definite direction and adhere to the temporarily sticky peaks of the deposit, causing a natural building towards the source of supply of dust.

The various processes described are taking place at the same time. Sulphuric acid is being manufactured at the base of the deposit by the catalytic action already explained. The strength of the acid is controlled by the local temperature, and where feed temperatures are high—between 250 deg. and 400 deg. Fah.—the acid strength is great enough to take alumina into solution. It should here be noted that it is only where the tube metal is at a sufficiently high temperature—as under "power station" conditions—that an acid sufficiently strong to dissolve alumina can be formed.

Hence an economiser which remains "clean" for six, twelve, or twenty months accumulates a thin, smooth scale, and then rapidly fouls with a hard, bonded, rough, stalagmitic deposit at an increasing rate.

The process is capable of being demonstrated in the laboratory.

Pulverised Fuel

It is still necessary to explain the comparative immunity of pulverised fuel fired plants from bonded economiser scales. It is well known that the fly ash from such plants consists largely of hollow spherical particles. These particles, since they are spheres, must have solidified before they reached the economiser. From what has gone before, it will appear that, in order to form a bonded deposit, these spheres would have to be appreciably attacked by sulphuric acid. There are, however, two factors operating against such attack. Other workers have noted that there is less sulphur trioxide in the gases from pulverised fuel firing than in those from stoker firing. The relative scarcity of sulphur trioxide would greatly increase the "immunity period."

There is, however, another important factor. It has been shown that, although a hydrated alumina is appreciably soluble in strong acid, a partly or completely dehydrated alumina is much less soluble. Each small grain of ash in a pulverised fuel fired plant has been subjected to a very high temperature—high enough to fuse and "spheroidalise" quite refractory ashes. It would seem, therefore, that the ash from pulverised fuel plants may contain aluminium compounds in comparatively insoluble forms. Unless, therefore, a pulverised fuel installation were run for a very long time, it is unlikely that a bonded deposit could be made to form on the economiser tubes. The "immunity period" during which the minute quantities of sulphuric acid in the gases collect on the tubes is very much longer, by reason of the scarcity of sulphur dioxide. When the film does form eventually the alumina in the fly ash is practically immune from attack, and the aluminium sulphate reaction never takes place.

CAUSES OF HIGH DEWPOINT TEMPERATURES IN BOILER FLUE GASES

By W. F. Harlow, Wh.Ex., A.M.I. Mech. E.

It is now widely recognised that the serious difficulties brought about by acid deposits in the air heaters and economisers of certain modern boiler plants fired by mechanical stokers are due to abnormally high dewpoint temperatures of the flue gases in such installations, and that the elevation of dewpoint is a result of the gases containing an excessive amount of sulphur trioxide.

One of the main difficulties in finding the

cause of these conditions has been that associated with the measurement of dewpoint temperature and sulphur trioxide content of dust-laden gases at high temperatures, and some difference of opinion exists as to the validity of the methods so far adopted. From evidence obtained over a number of years by the means available, however, and in the light of the considerations previously outlined, it appeared that the formation of sulphur trioxide occurred mainly after the gases had left the furnace and whilst they were passing through the boiler. It was suspected that some catalytic agent might be present in the boilers affected, and that this was responsible for converting a part of the sulphur dioxide that normally forms into sulphur trioxide in the affected plants.

A review of the substances which are known to be catalytic to gaseous reactions suggested that the iron oxide on the surface of the superheater tubes, and the encrusting scale which forms on such tubes, might both be capable of acting in the manner referred to, and it was therefore decided to test this by passing flue gases, which had a normal dewpoint indicative of low sulphur trioxide content, over such materials heated to the temperature which they acquire in a modern boiler.

Flue gases which were found to exhibit normal dewpoint characteristics were therefore taken from a small boiler fired by an automatic stoker of the underfeed type and these were passed through a mild steel tube, 3in. in diameter and 5ft. long, containing the materials to be tested. Arrangements were made to heat the tube by external means to any desired temperature up to 1200 deg. Fah. The dewpoint temperature of the gases was observed before and after the catalyst tube by a Cambridge dewpoint meter.

After some preliminary experiments it was found that when the gases were passed over rusty mild steel scrap heated to a temperature of 1000 deg. Fah., an increase in dewpoint was obtained, which indicated that an increase in sulphur trioxide content had been brought about.

In order to place this matter beyond doubt, glass water-cooled elements were introduced into the gas stream before and after the catalyst tube, the outer surfaces of the elements being maintained at the same temperature of 140 deg. Fah., which was somewhat above the dewpoint temperature of the gases before treatment. The gases were then passed through the apparatus (Fig. 1) for thirty minutes. After

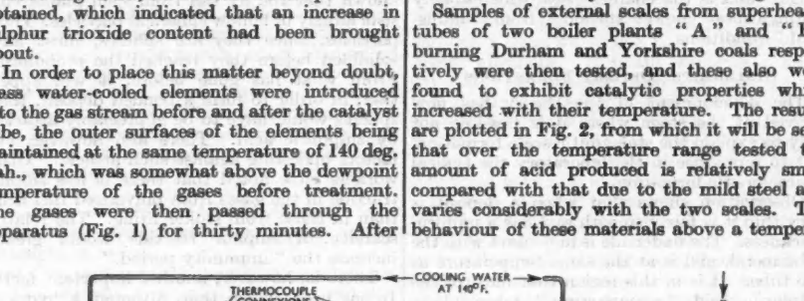


FIG. 1—*Sectional Diagram of Apparatus*

this time it was found that the element preceding the catalyst tube was covered with an apparently dry dust, whereas that following the catalyst tube was covered by a copious deposit of dew. The dew was found to be sulphuric acid, as shown by the precipitate formed when the deposits were washed off the elements, filtered, and then filtrate treated with barium chloride. It will be observed that the deposit obtained before the catalyst tube was practically free from sulphuric acid. It is of interest to note that the gases impinging on the first element were at a temperature of about 350 deg. Fah., whereas the gases meeting the second element were at a much higher temperature due to their passage through the heated tube.

It was found that the amount of dew varied with the temperature of the catalyst, and tests were therefore carried out with the mild steel scrap heated to various temperatures, the amount of sulphuric acid being determined in each case by gravimetric means. The results are plotted in Figs. 2 and 3, from which it will be seen that a small but gradually increasing amount of acid is formed, even at comparatively low temperatures, and at about 800 deg. Fah. this commences to increase sharply until 1100 deg. Fah. is reached, after which it decreases.

The following materials were then tested when heated to 1000 deg. Fah.:—

(1) "Parkerised" mild steel.
(2) Nickel-plated mild steel.
(3) Stainless steel (12 per cent. Cr, 1 per cent. Ni).
(4) Mild steel treated by the "Penetral" process (surface of steel converted to aluminium ferride).

In each case oxidation of the material occurred

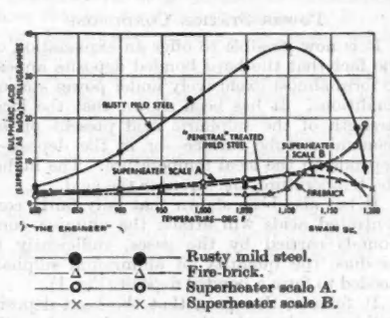


FIG. 2—*Variation in Weight of Sulphuric Acid with Temperature*

in the first thirty minutes and acid was produced, although in the case of item (4) the oxidation and catalytic action was slight.

Samples of external scales from superheater tubes of two boiler plants "A" and "B" burning Durham and Yorkshire coals respectively were then tested, and these also were found to exhibit catalytic properties which increased with their temperature. The results are plotted in Fig. 2, from which it will be seen that over the temperature range tested the amount of acid produced is relatively small compared with that due to the mild steel and varies considerably with the two scales. The behaviour of these materials above a temperature of 1200 deg. Fah. could not be investigated owing to the limitations of the apparatus, but it is thought unlikely that the conversion would increase greatly owing to the diminishing percentage of sulphur trioxide which can exist as the temperatures are further advanced. Tests at higher temperatures should, however, be carried out.

In the case of these scales, which contained sulphates, it was found that acid was formed on the element at the outlet of the catalyst tube when air only was passing over the heated material, due no doubt to decomposition of ferric sulphate. The tests with flue gases were therefore carried out after the scales had been strongly heated in a current of air for several hours until no further deposit of acid was obtained. Both scales were found to contain a percentage of iron oxide, as is usual with such deposits, and since it was not clear whether this oxide or the siliceous material was the catalytic agent, a sample of fire-brick was next tested. Catalytic action was again established, particularly at high temperatures (see Fig. 2).

From the above results it seems clear that iron oxide, superheater scale, and refractory fire-brick will each catalyse the oxidation of sulphur dioxide to sulphur trioxide in boiler flue gases, providing the surface temperature of these materials is sufficiently high, and it is suggested that in these important facts lies the explanation for the high dewpoint temperatures and resulting troubles in certain modern stoker-fired boiler plants to-day.

It is obvious that for catalysts to proceed effectively, the gases must make intimate contact with the catalysing surface which must be at the requisite temperature. Both these conditions may be realised when the gases pass over the superheater tubes, which are, of course, the hottest parts of the boiler heating surface.

The temperature of the tube is governed mainly by that of the steam inside and, to a lesser extent, by the temperature of the flue gases on the outside. This is because the coefficient of heat transfer from the tube to the steam is much higher than from the gases to the tube due to the higher velocity and density of the steam compared with the flue gases.

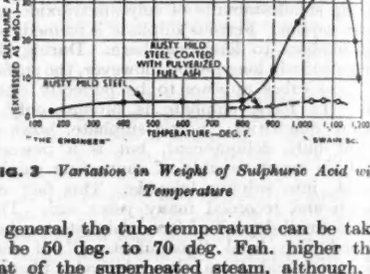


FIG. 3—*Variation in Weight of Sulphuric Acid with Temperature*

In general, the tube temperature can be taken to be 50 deg. to 70 deg. Fah. higher than that of the superheated steam, although, of course, this will vary to some extent with the design conditions. Any internal scale or reduction of steam flow will naturally elevate the tube temperature considerably.

A study of the steaming conditions and operating results of a large number of affected and unaffected stoker-fired plants shows that the incidence of this trouble is closely related to the degree of superheat temperature, on which the temperature of the exterior surface of the tube and encrusting scale largely depends. During the past decade superheat temperatures have advanced from about 700 deg. Fah. to 850 deg. to 950 deg. Fah. at the present time, and the surface temperature of the tubes and of the scale thereon increased accordingly until this has now reached the point where catalysis of sulphur dioxide to a serious extent can take place.

SUPERSONIC WAVES AND DEFECTS IN MOTOR-CAR TYRES.—Supersonic vibrations are being used to detect defects in motor tyres in a new device perfected by the Goodyear Tyre and Rubber Co. The chief purpose of the new device is to locate so-called ply separations—that is, air spaces caused by separation of the layers of fabric composing a tyre. The tyre, dismounted from the rim, is hung on two rollers in such a way that the bottom portion of the tyre passes through a shallow tank of water as the tyre is revolved. Sound waves of supersonic frequency are generated in the water by a nickel rod, set in vibration by means of a high-frequency electric current, which passes through a coil of wire surrounding the rod. The vibrations are picked up by a microphone, mounted so as to be always inside the portion of the tyre which is immersed in the water. The microphone operates a relay box equipped with a green and a red light. As long as the tyre is solid, the supersonic vibrations pass through it with full intensity to the microphone. This causes the green light to stay lit. If there is a separation in the tyre, the supersonic waves are reflected back by the air gap and do not get through the tyre with full intensity. This causes the green light to go off and the red light to appear.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.

Electrical Developments

The Canadian Electrical Association has proposed a 1000 million dollar post-war programme, according to *The Foreign Commerce Weekly*, the official publication of the United States Department of Commerce. A special committee has been appointed to co-ordinate the plans of the Association members along lines meeting with Government approval. Among the general objectives of the programme will be the conversion of factories from war to peacetime production; the development of rural electrification; modernisation and extension of power systems; the manufacture of electrical appliances for low-income groups; electrification of transport lines; and maximum employment. The output of central electrical stations in Canada during the first six months of 1943 totalled 19,624,395,000 kWh, an increase of more than 1,000,000,000 kWh over production during the corresponding period of 1942. The growth of the Nova Scotia Power Commission is referred to. The Commission has grown steadily since its establishment in 1919. In 1922 the Commission delivered 5,185,538 kWh to its customers. In the twelve-month period ended November 30th, 1942, deliveries totalled 208,997,430 kWh. The pulp and paper industries of the province utilised 71·5 per cent. of the power sold by the Commission during the last fiscal year. Interesting developments in the electrical field have taken place in China. Five provincial power-houses are in operation in Kiangsi Province, China. These are located in Kian, Kanhsien, Taiho, Tayo, and Kwangtseh. There are also about twenty commercial power companies. An electrical appliances factory was established in Kiangsi Province in 1942 after the merger of the Provincial Radio Manufacturing Concern and the Min Sen Battery Factory. Electric cells and various types of telecommunication apparatus are being produced. Owing to the prolonged drought and the poor condition of machinery in the power stations in French Mcrocco, particularly at the steel plant in Casablanca, restrictions on the consumption of electric power have been instituted.

Control of Iron and Steel

The Minister of Supply has made the Control of Iron and Steel (No. 32) Order (S.R. & O., 1943, No. 1530), which came into force on November 3rd, 1943. This Order revokes and remakes in consolidation form the Control of Iron and Steel (Nos. 15–20, 22, 23, 26, 28, and 31) Orders, 1941–43. The Order also includes the following new provisions:—(1) Extension of control to niobium and tantalum ores and all chemical compounds of molybdenum, tungsten, or vanadium (exclusive of catalysts or pigments). (2) Permits stockholding merchants to prepare material supplied against an authorisation under the distribution scheme to the extent covered by that authorisation. In other cases, stockholders may perform simple operations, such as cutting and holing. (3) Where a resale is made at the request of the Minister of Supply, involving additional transport costs, he may authorise an addition to the maximum controlled price. (4) Permits the purchase without authority of up to two rolls, not exceeding £3 in value, of used wire netting in any calendar month. The Order also authorises a number of price changes.

The Pig Iron Market

Generally, the British pig iron position seems to have improved during recent months with the arrival in this country of ore from North Africa, although larger supplies would be welcome. The easier conditions which developed in the low and medium-phosphoric pig iron and refined pig iron positions, as a result of the larger outputs of these descriptions through increased quantities of higher-grade ore becoming available, have been reflected in an improved situation in the market. The general engineering and allied foundries, which not long ago were experiencing some difficulty in securing the type of pig iron they required, are now obtaining their full quotas. At the same time, the demand for low and medium-phosphoric pig iron has declined as well as for ordinary foundry iron. This is due to changes in the war production programme, which have led to some products coming more in demand than others. Some of the foundries find that the demand for the particular castings on which they have been engaged for some time has declined and as a result have found themselves with more pig iron than they wanted. This has been chiefly noticeable amongst the jobbing foundries; but, at the same time, there is a heavy demand generally for castings for Government work. The decline in the demand has also affected the refined pig iron market and there are few cases in which the producers are not able to meet their customers' requirements with comparative ease. The conditions in the light castings industry have only slightly improved during recent weeks, and the light casting foundries are able to obtain their full requirements of high-phosphoric pig iron, which is being produced in considerable quantities by the Midland furnaces. The Iron and Steel Control is showing considerable liberality in the distribution of this class of pig iron. The demand for hematite is active and in excess of the supply, so that the Iron and Steel Control has to exercise care in its distribution and no hematite is allocated for work for which any other description of pig iron will serve. The production of basic pig iron is at a high level and the steel industry is obtaining its full requirements.

Scotland and the North

There has been no relaxation in the great activity ruling at the Scottish iron and steel works. Adjustments have had to be made to meet changes in the Government's war production programme, but these appear to have been successfully carried out, and the steel production in Scotland on an ingot basis is on a very heavy scale. There is an intensive demand from the engineering industry for special steel, but there has been a recession in the volume of business in alloy steel, and consumers are obtaining their requirements of this description much more freely than a few months ago. The demand for plates has expanded, if anything, during the past few weeks, particularly for the lighter sizes. In this department production barely keeps pace with the demand. Very heavy quantities continue to pass to the shipyards, whilst tank makers, wagon builders, and the engineering industry are absorbing large tonnages. It is expected, however, that relief will be experienced in this department when new plant, which is under construction, is brought into use. Locomotive builders are busy, whilst the marine engineering establishments have as much work as they can undertake during the current delivery period. A large tonnage of steel has also been absorbed by crane makers and by power plant makers. Whilst it is not difficult to place orders for heavy joists and angles for fairly near delivery, the demand for lighter sections is heavy, and some producers are extending their delivery dates. The iron and steel consuming trades in the Lancashire districts are fully employed and there is an outstanding demand for plates of all sizes. Business in structural steel is variable, but the whole production of the lighter sections seems to be quickly taken up. On the other hand, makers of heavy steel sections could do with more work. The demand for steel bars appears to be steadily expanding, and large quantities are passing into consumption. The engineering industry, in particular, is taking up important supplies of the large-diameter bars; whilst small bars and ferro-concrete bars are in active demand. The steel works on the North-West Coast are fully employed, and have a large volume of orders in hand.

The Midlands and South Wales

The volume of new business coming forward in iron and steel has declined somewhat, perhaps not to a great extent, but it is the more noticeable because of the insistent demand for practically all iron and steel products which has characterised the position for so long. The producers of iron and steel are already committed to fulfilling orders which will absorb the whole of the estimated production for some months, and in the majority of cases cannot see their way to accept fresh business for delivery during the current period. In these conditions the volume of new business is limited to a large extent to requirements against which allocations will be issued at the end of the year for delivery in the first period of 1944. The Midland re-rolling industry is working at capacity and is carrying a heavy weight of orders for light structural sections, small steel bars, special sections, and sheets. The accumulation of orders is sufficient to keep most of the re-rolling firms fully employed for the remainder of this year and into the early part of next. The supply of raw materials to this industry is more satisfactory than for a long time. Billets from English and Welsh works are reaching consumers with regularity and in adequate quantities, and in a number of cases users have been able to build up useful stocks of billets and sheet bars. It is still necessary for re-rollers to take up a certain amount of defective billets and crops, but for the time being there is not so great an outlet for this material as recently. One result of the improvement in the home production and the larger supplies of primes and defectives available to the re-rollers has been the practical cessation of the withdrawals from the stocks of imported semis held by the Iron and Steel Control. The structural steel position is satisfactory and although there is a considerable demand for the lighter sections, the producing works are maintaining a good rate of deliveries. The volume of business in heavy structural sections, however, is still comparatively poor. The sheet works have sufficient orders in hand to keep them fully employed until well into 1944, and buyers are finding it difficult to place orders for earlier delivery, although here and there orders for material required for urgent priority work are accepted. The iron and steel industry in South Wales is operating at capacity, and in particular the order books of the works producing plates are congested. The demand shows no signs of relaxing and the works will be fully employed for an indefinite period. The sheet works also are experiencing an active demand and few of the makers are in a position to accept fresh orders for delivery this year. The tinplate industry is operating under difficulties. The market has shown signs of slightly more activity recently; little export business can be transacted owing to the regulations. Rather more sales have been made in the home market of late and the improvement in the demand has extended to the black plates.

The North-East Coast and Yorkshire

Little change has occurred in the iron and steel position on the North-East Coast. The industry is assured of full-time operations until the end of the year and beyond, but the fact that this has checked the flow of new business, since the works are unable to promise anything but prolonged delivery, has not greatly influenced the position. Interest now seems to be centring upon the new allocations which will be given out at the end of the present quarter. Great activity prevails at the re-rolling works, which are taking up large tonnages of semis. Since the system of weekly allocations has been in operation the re-rollers have little to grumble about so far as deliveries are concerned, and the fears which at one time were entertained by some of these works seem to have entirely disappeared. Practically all the semis now used by the re-rolling works are of British manufacture, and considerable quantities of defectives and crops are being used, as well as primes. The withdrawals from the stocks of imported semis have almost ceased. The huge demand for plates is taxing the resources of the rolling mills. Shipyards and ship repairing yards account for the greater part of the production, but wagon builders, tank makers, and heavy engineers are absorbing big tonnages. The sheet makers also have enough work in hand to keep them fully employed until the end of the year, and only urgent and important orders can be accepted for delivery before that date. The resources of the sheet mills are also taxed by the demand for thin plates. There is a strong demand all round for supplies of light structural sections and small steel bars, and the order books of many of the re-rolling works will be congested for some time to come. The demand for heavy sections, however, is still on the easy side and producers are able to give fairly reasonable delivery for this description. Although most of the Yorkshire iron and steel works are fully committed well into 1944, some consumers have found it possible to place urgent orders for plates and special steels. The demand for the latter is not so insistent as was the case a month or two ago, but it is of considerable proportions. The increased production in this class of steel, however, has greatly relieved the position and deliveries can be obtained without a lengthy delay.

Iron and Steel Scrap

The scarcity of the best quality iron and steel scrap has become, if anything, more pronounced, and at the same time the demand for this class of scrap has increased, largely owing to the expansion in the production of special steels. On the other hand, there is no lack of the light and inferior descriptions of scrap, and many of the consuming works have larger stocks of this kind than they require. The demand is principally for heavy mild steel scrap and basic steel, and during the past week or two reserves have been drawn upon to a considerable extent. Some of the steel makers have been driven to use large quantities of heavy wrought iron and steel and bundled steel cuttings, of which there are plenty available. Generally speaking, more active business conditions prevail in the scrap market than for some time, but difficulties have been experienced owing to traffic troubles, but these are being dealt with and steadily removed. There is an insistent demand for good heavy mild steel scrap cut to furnace and foundry sizes, and consumers are eagerly taking up any quantities offered.

Notes and Memoranda

Rail and Road

THE L.M.S. BALERNO BRANCH.—The Balerno branch line, immediately south of Edinburgh, on the London Midland and Scottish Railway, was closed to passenger traffic on Monday, November 1st.

A HIGHWAY FOR NORTH AFRICA.—Since the occupation of North Africa by the Allies was completed, the construction of an up-to-date road is being developed along the north coast of the continent. Under an arrangement between the British and Egyptian authorities, the widening and improvement of the coastal road from Alexandria to Mersa Matrouh is being undertaken by the Egyptian Government, and the work thence to the Libyan border by the British Government. The restoration and improvement of transport facilities in Morocco and Algeria is in the hands of the Allied Forces commanded by General Eisenhower.

THE "CORONATION SCOT."—The British streamlined train, the "Coronation Scot," which was exhibited at the New York World's Fair and for the past three years has been in the shop yards of the Baltimore and Ohio Railroad, has been acquired by the U.S. Government and moved to Jeffersonville, Ind., where it is to be used for officers' quarters under the jurisdiction of the Quartermaster-General of the Army. The train has been in the United States since the end of the N.Y. World's Fair in 1940, since it was deemed inadvisable to attempt to send it back to England because of shipping hazards. The streamlined locomotive and tender used on the train were, however, safely returned to England a few months ago.

Miscellanea

UNEXPECTED GOLD.—An American exchange reports that when road builders were constructing a highway along the American River they cut away a hillside and exposed several narrow seams of quartz. Following a rainstorm, the bank sloughed and one of the workmen found free gold in the formation. In two months the deposit yielded gold to the value of 30,000 dollars.

LEAD FROM INDIA.—The production and smelting of lead ores in India are being closely investigated. Since the separation of Burma from India, and the subsequent passing of that country into enemy hands, the necessity for restarting and developing the lead industry in India has become urgent. The lead resources of India are substantial, and the Utilisation Branch of the Geological Survey of India has carried out considerable prospecting work, particularly at the old lead-zinc mines of Jawar in Udaipur State.

THE LATE MR. W. GUY HODGE.—We regret to learn that Mr. W. G. Hodge, who represented the British Thomson-Houston Company, Ltd., in South Wales for twenty-five years, died at his home in Swansea on November 3rd. Mr. Hodge was born on August 24th, 1861, and served his engineering apprenticeship in the Nine Elms Works of the London and South-Western Railway. He afterwards worked for Messrs. Merryweather and Sons, Greenwich, Robert Hammond and Co., London, and several firms of mechanical and electrical engineers in Manchester, before joining the staff at the B.T.H. works in June, 1904. After spending three years in the power and mining department, and in the B.T.H. Manchester office, he was transferred to Swansea, and was the company's district manager from 1907 until his retirement at the end of 1932. He was very well known in South Wales engineering circles, particularly for his work in connection with the electrical equipment of collieries and rolling mills.

THE ELECTRON MICROSCOPE AND SYNTHETIC RUBBER.—Differences between natural and synthetic rubber were demonstrated recently with the aid of an electron microscope in the new research laboratory of the Goodyear Tyre and Rubber Company, at Akron. Studies with the electron microscope reveal that synthetic latex consists of particles of smaller average sizes and greater uniformity. In natural rubber latex the average size of a particle is 10 millionths of an inch. In the synthetic rubber latex it is 2·5 millionths of an inch. Moreover, the particles of natural rubber latex range in size from as little as 4 millionths of an inch to as much as 160 millionths. On the other hand, the range of the synthetic particles is only from 0·8 to 7·2 millionths of an inch. These difficulties, it is held, explain many of the reasons why synthetic rubber requires different handling from natural rubber. The small, uniform size of synthetic latex explains in whole or in part (1) why synthetic latex has a much greater mechanical stability, (2) why it is impossible to concentrate it by centrifuging, as is commonly done with natural latex, (3) why it has a greater viscosity than natural latex for a given content of solids, and (4) why it impregnates fabrics more readily.

A LONG ROPEWAY.—Turkey has now a 3-mile ropeway. It has been installed for the conveyance of coal from the mines to the port of Zongouldak, on the Black Sea. It will double the shipments of coal from that port.

A MISSION FROM WASHINGTON.—Two distinguished engineers, Dr. Harvey N. Davis and Dr. Donald B. Keyes, are on a mission to this country from the Office of Production Research and Development, which operates under the War Production Board, Washington. Dr. Harvey Davis, the Head of the Office, is also President of the Stevens Institute of Technology, Hoboken, N.J., and is a Past-President of the American Society of Mechanical Engineers. Dr. Donald Keyes, the Chief of the Chemical Industries Branch of O.P.R.D., is Head of the Chemical Engineering Department, University of Illinois. They are visiting this country to discuss with the Ministry of Production and other Government Departments the exchange of technical information between this country and the U.S.A. They hope to encourage experts on both sides of the Atlantic to exchange visits and inspect each other's factories and factory operations.

Personal and Business

DR. W. T. GRIFFITHS has been nominated President of the Intitute of Metals.

SIR MALCOLM FRASER has been elected chairman of Callender's Cable and Construction Company, Ltd.

MR. WILLIAM GLASS, A.M.I. Mech. E., director and works manager, has been appointed deputy managing director of Johnson and Phillips, Ltd. Mr. Stanley J. Passmore and Lieut.-Colonel R. W. C. Reeves, A.M.I.E.E., Royal Signals, have been appointed directors of the company.

MR. R. P. CRITCHLEY, L.N.E.R. district locomotive superintendent, Edinburgh, has been appointed district locomotive superintendent, Glasgow, in succession to Mr. G. W. Phillips, who has retired. Mr. B. P. Blackburn, district locomotive superintendent, Burntisland, has been appointed district locomotive superintendent, Edinburgh, to succeed Mr. Critchley.

THE GENERAL COUNCIL of the Combustion Appliance Makers' Association has appointed Mr. S. McEwen Honorary Treasurer and Vice-President of the Association, in succession to Mr. E. W. Robey, who has retired for reasons of health. Mr. H. Lindars has been nominated for re-election as Chairman of the Council of the British Coal Utilisation Research Association for the three years ending December, 1946.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association for Scientific Photography

Saturday, Nov. 13th.—Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Electrical Engineering: The Photography of Cathode Ray Oscillograph Traces," N. Hendry and W. Nethercot. 2.30 p.m.

Bradford Engineering Society

Monday, Nov. 15th.—Technical College, Bradford. "The Effect of the New Educational Plans on the Engineering Industry," H. L. Haslegrave. 6.45 p.m.

British Association of Refrigeration

Thursday, Nov. 18th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Some Notes on the Development of Extreme Low-Temperature Refrigeration," E. G. Rowledge and A. O'B. Brandon. 5.30 p.m.

Chartered Surveyors' Institution

Wednesday, Nov. 17th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. General meeting of Quantity Surveyor Members. 5.30 p.m.

Institute of Economic Engineering

Sunday, Nov. 14th.—Waldorf Hotel, Aldwych, W.C.2. "Production Planning and Control," W. G. Webb 2.30 p.m.

Institute of Transport

To-day, Nov. 12th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Luncheon and address by P. Noel Baker. 12.45 for 1.15 p.m.

Saturday, Nov. 20th.—METROPOLITAN GRADUATES: Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Railway Accounting and the Engineer's Department," J. A. R. Turner. 2.15 p.m.

Institution of Automobile Engineers

Saturday, Nov. 13th.—N.W. CENTRE: Engineers' Club, Albert Square, Manchester. "Performance Characteristics of Steering Gear," H. N. Charles. 3 p.m.

Sunday, Nov. 14th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "The Sports Car: Its Past and Future," C. Kimber. 3 p.m.

Institution of Electrical Engineers

Saturday, Nov. 13th.—N. MIDLAND STUDENTS: Griffin Hotel, Boar Lane, Leeds. "The Protection of Power Transformers," H. W. Oldham. 2.30 p.m.

Tuesday, Nov. 16th.—WIRELESS SECTION: Savoy Place, Victoria Embankment, W.C.2. Discussion, "The Rôle of Ultra-High Frequencies in Post-War Broadcasting." 5.30 p.m.

Friday, Nov. 19th.—MEASUREMENTS SECTION: Savoy Place, Victoria Embankment, W.C.2. "Instrument Transformers," A. Hobson. 5.30 p.m.

Monday, Nov. 22nd.—Informal meeting. Savoy Place, Victoria Embankment, W.C.2. "The Administrative Structure of Electricity Undertakings," G. V. Harrap. 5.30 p.m.

Tuesday, Nov. 23rd.—N. MIDLAND CENTRE, Great Northern Hotel, Leeds. "The Future of the Domestic Wiring Installation," W. J. H. Wood, F. Jackson, G. Smith, and E. Jacobi. 6 p.m.

Wednesday, Nov. 24th.—WIRELESS SECTION: Savoy Place, Victoria Embankment, W.C.2. "Enemy Airborne Radio Equipment," C. P. Edwards. 5.30 p.m.

Thursday, Nov. 25th.—Savoy Place, Victoria Embankment, W.C.2. Nikola Tesla Special Commemorative Meeting. Lecture by Dr. A. P. M. Fleming. 3 p.m.

Institution of Engineers-in-Charge

Saturday, Nov. 13th.—Magnet House, Kingsway, W.C.2. "Sound Reproduction Equipment," H. D. Murdoch. 2 p.m.

Institution of Mechanical Engineers

To-day, Nov. 12th.—SCOTTISH BRANCH: Robert Gordon's Technical College, Aberdeen. "Remember the Past and Look to the Future," Professor F. C. Lea. 7.45 p.m.—Storey's Gate, Westminster, S.W.1. Symposium on the Reclamation of Worn Parts. 5.30 p.m.

Monday, Nov. 15th.—MIDLAND GRADUATES: James Watt Memorial Institute, Great Charles Street, Birmingham. "The Theory of Stationary and Running Dry Friction on Disks and Annuli," G. A. G. Fazekas. 7 p.m.

Thursday, Nov. 18th.—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham. "Industrial Development in the Dominions," M. L. Oliphant. 4.30 p.m.

Friday, Nov. 19th.—Storey's Gate, Westminster, S.W.1. Hawksley Lecture. "Gyroscopic Principles and Applications," C. E. Inglis. 5.30 p.m.

Saturday, Nov. 20th.—SOUTHERN BRANCH: Polygon Hotel, Southampton. "Remember the Past and Look to the Future," F. C. Lea. 2 p.m.—N.W. GRADUATES: Engineers' Club, Albert Square, Manchester. "Colliery Mechanical Engineering," F. E. Rainford. 2.30 p.m.

Institution of Production Engineers

Saturday, Nov. 13th.—YORKS SECTION: Hotel Metropole, Leeds. "Output and Environment," K. G. Fenelon. 2.30 p.m.

Wednesday, Nov. 17th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Birmingham. Film, "Resistance Welding." 7 p.m.

Friday, Nov. 19th.—N.E. SECTION: County Hotel, Newcastle-upon-Tyne. "Surface Finish and its Application to Practical Problems," G. Schlesinger. 6.15 p.m.

Saturday, Nov. 20th.—PRESTON SECTION: Atlas Ironworks Canteen, Blackburn. "Metallic Arc Welding from the Production Engineer's Viewpoint," W. J. Vernon. 2.30 p.m.

Iron and Steel Institute

Tuesday, Nov. 23rd.—Modern School, Cole Street, Scunthorpe. "Review of Basic Open-Hearth Practice at an Australian Plant," R. L. Knight. 7.30 p.m.

Junior Institution of Engineers

To-day, Nov. 12th.—39, Victoria Street, S.W.1. Annual general meeting. 6.30 p.m.

Friday, Nov. 19th.—39, Victoria Street, S.W.1. Informal meeting. 6.30 p.m.

Keighley Association of Engineers

To-day, Nov. 12th.—Victoria Hotel, Keighley. "The Young Production Engineer: His Training and Prospects," J. D. Scaife and J. Hill. 7.30 p.m.

Manchester Association of Engineers

Saturday, Nov. 13th.—Engineers' Club, Albert Square, Manchester. "The Control of Hydraulic Power." E. Bruce Ball, jun. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Wednesday, Nov. 24th.—STUDENT SECTION: Bolbec Hall, Newcastle-upon-Tyne. "Yacht Design," O. Clemmetsen. 6.45 p.m.

Friday, Nov. 26th.—Mining Institute, Newcastle-upon-Tyne. "Notes on the Design and Performance of Water-Tube Boilers for Cargo Steamers," W. Sampson. 6 p.m.

Royal Society of Arts

Wednesday, Nov. 17th.—John Adam Street, Adelphi, W.C.2. "The Coming of Age of the B.B.C.," Stuart Hibberd. 1.45 p.m.